WoodWorks™
WOOD PRODUCTS COUNCIL

Designing and Constructing Mid-Rise and Taller Mass Timber Buildings

Presented on: 6/15/2021

Presented by:
Mike Romanowski, SE
Chelsea Drenick, SE

Photo: Structurlam

WHAT WOODWORKS DOES

Albina Yard
LEVER Architecture | Photo: LEVER Architecture

The Hudson
Mackenzie | Photo: Christian Columbres

Venture Capital Office HQ
Paul Murdoch Architects | Photo: Eric Staudenmaier

Designing a wood building? Ask us anything.

WoodWorks™
WOOD PRODUCTS COUNCIL

FREE PROJECT SUPPORT • EDUCATION • RESOURCES

Nationwide support for the code-compliant design, engineering and construction of non-residential and multi-family wood buildings.

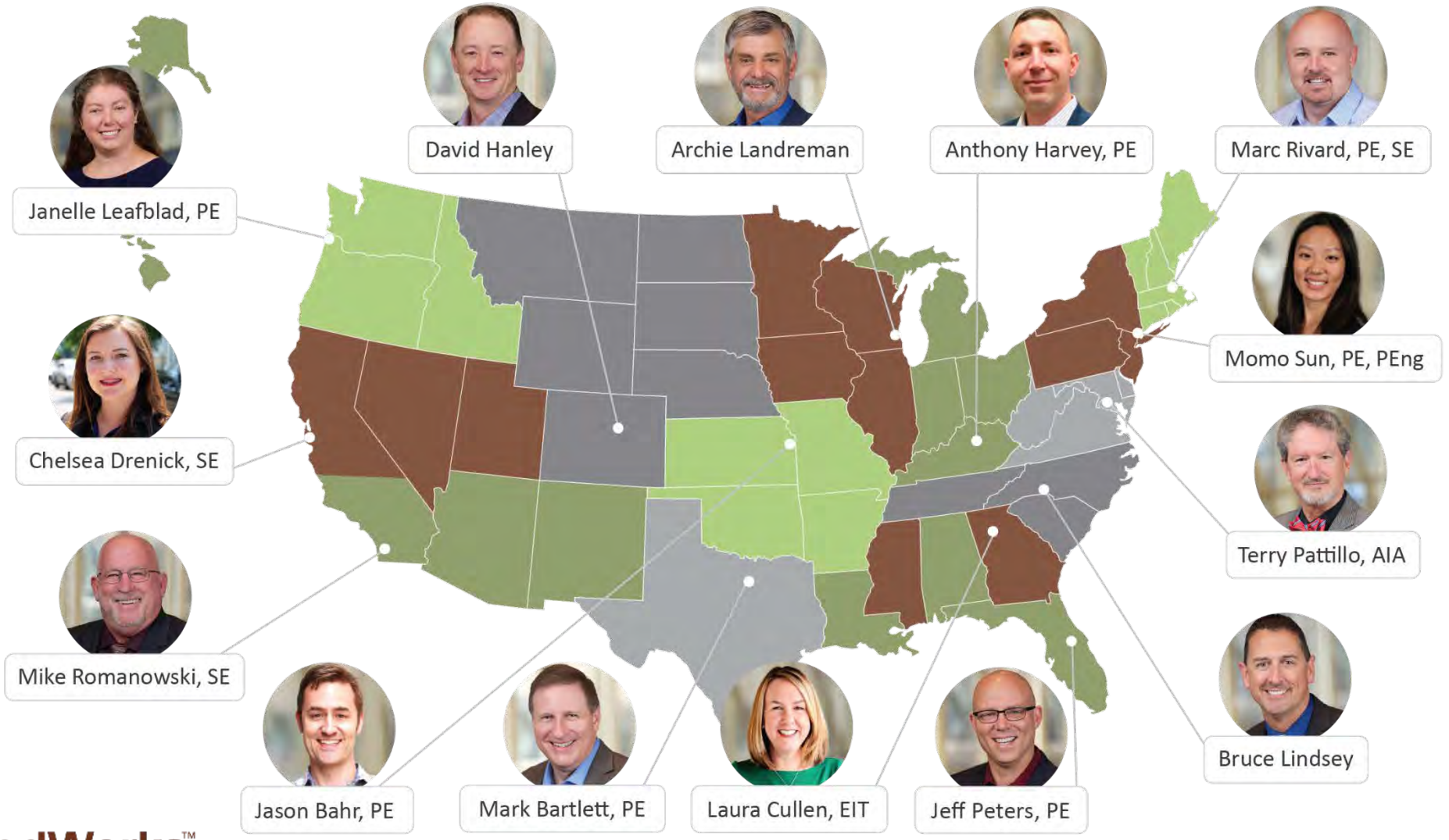
- Allowable Heights/Areas
- Construction Types
- Structural Detailing
- Wood-Framed & Hybrid Systems
- Fire/Acoustic Assemblies
- Lateral System Design
- Alternate Means of Compliance
- Energy-Efficient Detailing
- Building Systems & Technologies

River Edge, Kitchen & Associates
photo courtesy of McAlvain Construction

woodworks.org/project-assistance • help@woodworks.org

MULTI-FAMILY/MIXED-USE • EDUCATION • OFFICE • RETAIL • INDUSTRIAL • CIVIC • INSTITUTIONAL

Design Professionals: **One-on-One Support and Assistance**



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Forestry Innovation Investment®

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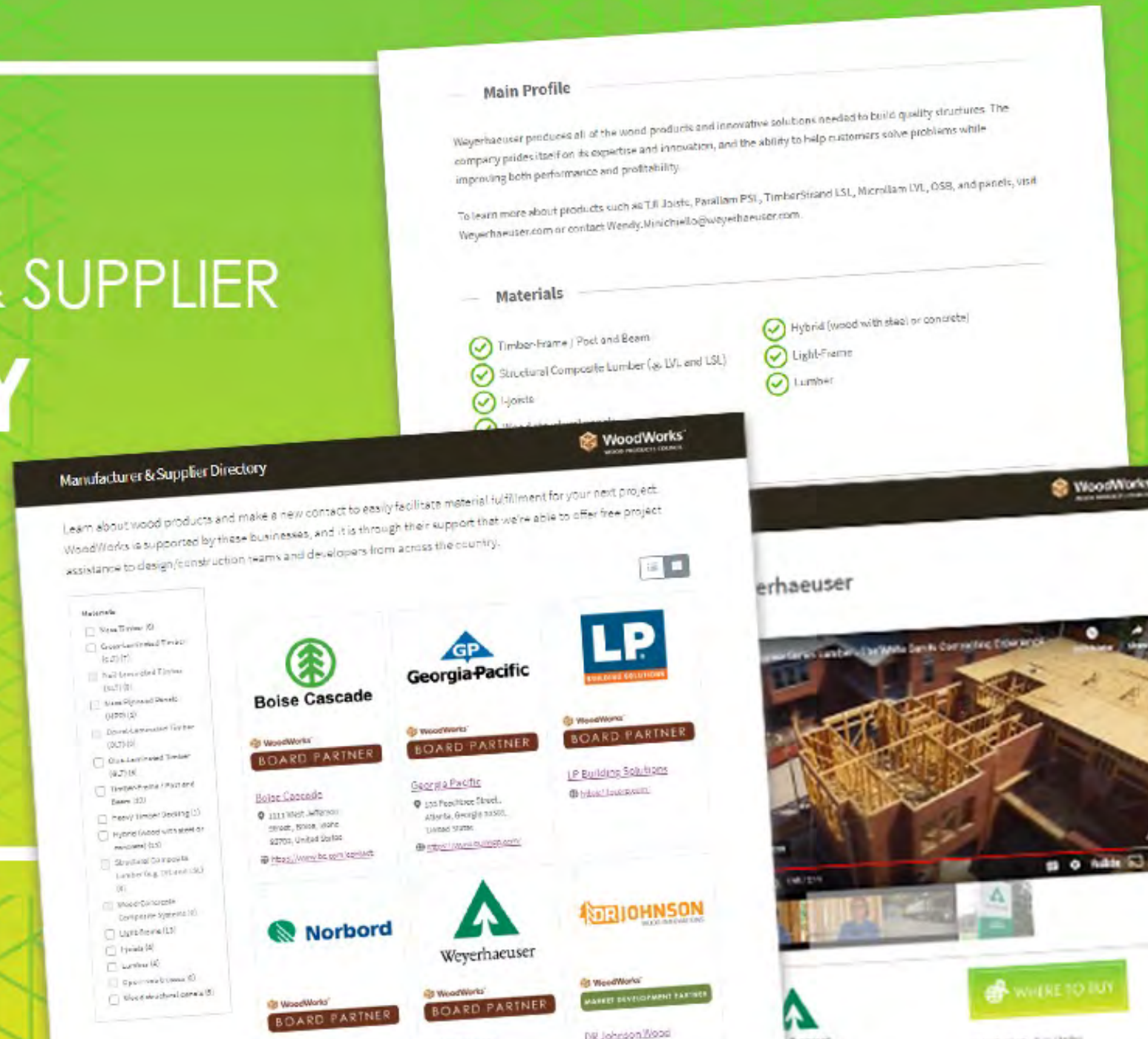

Current State of Mass Timber Projects

As of March 2021, in the US, **1,114** multi-family, commercial, or institutional projects have been constructed with, or are in design with, mass timber.

https://www.woodworks.org/publications-media/building-trends-mass-timber/

Source: WoodWorks, March 31, 2021

** This total includes modern mass timber and post-and-beam structures built since 2013*

UPCOMING ONLINE EVENTS

WEBINARS

July 14 | **Save the Date**

August 11 | **Save the Date**

WORKSHOPS & SYMPOSIUMS

July 22 & 27| **A Detailing Deep Dive: Fire, Acoustics and Structural Detailing in Mid-Rose Multi-Family**

August 20 | **Construction Management Workshop**

November 4 | **Symposium – Save the Date**

Visit www.woodworks.org for a complete list

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Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with AIA CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Innovative mass timber buildings are experiencing significant growth in both market opportunity and height with the new 2021 International Building Code tall wood code provisions. Growing this industry requires an understanding from both designers and seasoned construction professionals of how to construct efficiently, navigate jurisdictions new to mass timber, and manage the procurement risks to deliver the dream of a new and optimized building system. This presentation will address how the development, architectural, engineering, and construction community can achieve success with mass timber projects of various scales and typologies.

Learning Objectives

1. Explore benefits of mass timber, including fast construction, labor savings, light weight, aesthetic value, and wood's contributions to a healthy indoor environment.
2. Discuss opportunities presented by the new construction types for tall wood buildings, along with associated code-compliance and fire life safety considerations, challenges, and tips for successful project delivery.
3. Use case study presentations to illustrate innovative and code-compliant examples of mass timber projects throughout the U.S., highlighting strategies for MEP routing and grid layout.
4. Explore best practices for interaction between manufacturer, design team and preconstruction manager that can lead to cost efficiency and safety on site.

PRESENTATION OUTLINE

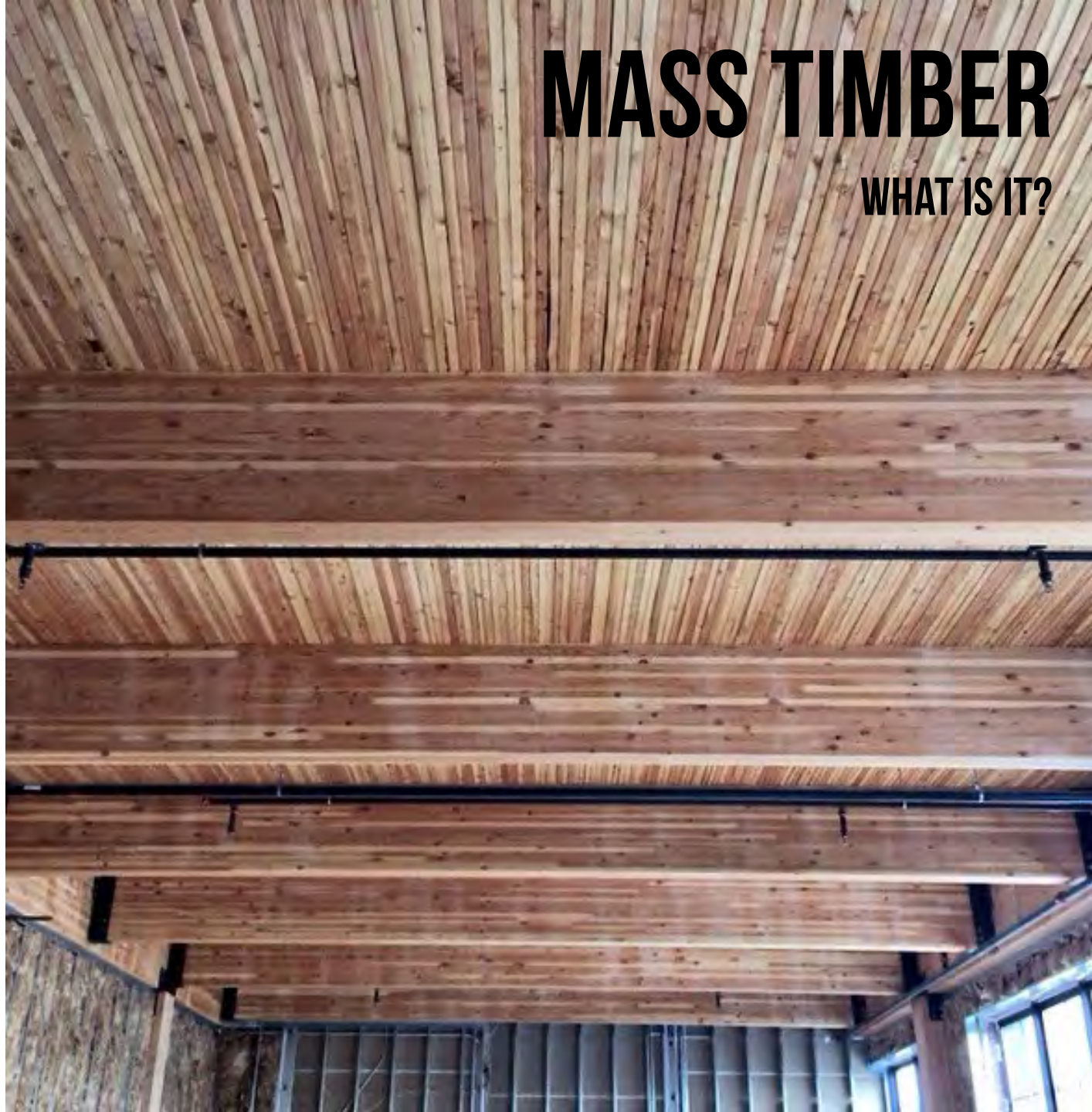
1. MASS TIMBER OVERVIEW
2. TALL WOOD PROVISIONS
3. CONSTRUCTION MANAGEMENT
4. BUSINESS CASE FOR MASS TIMBER

MASS TIMBER OVERVIEW

MASS TIMBER

WHAT IS IT?

MASS TIMBER IS A CATEGORY OF FRAMING STYLES OFTEN USING SMALL WOOD MEMBERS FORMED INTO LARGE PANELIZED SOLID WOOD CONSTRUCTION INCLUDING CLT, NLT OR GLULAM PANELS FOR FLOOR, ROOF AND WALL FRAMING



HEAVY TIMBER

Federal Center South, Seattle, WA
Photo: Benjamin Benschneider

MASS TIMBER

Bullitt Center, Seattle, WA
Photo: John Stamets

Mass Timber Framing Systems

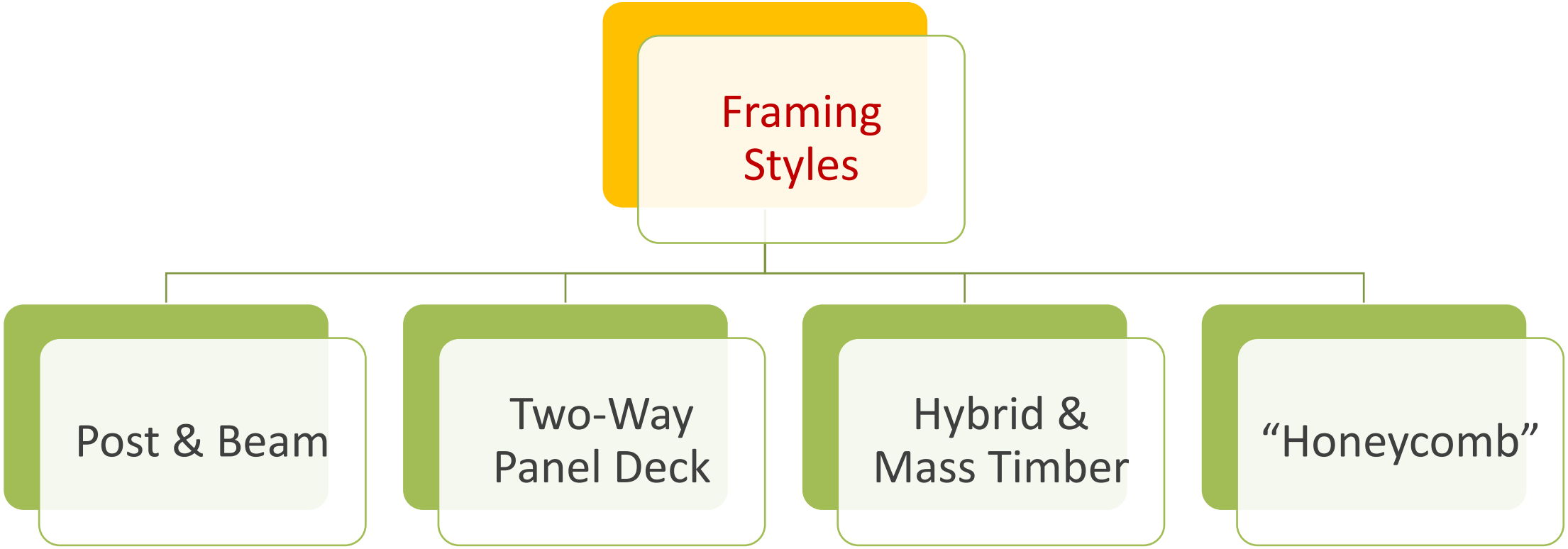


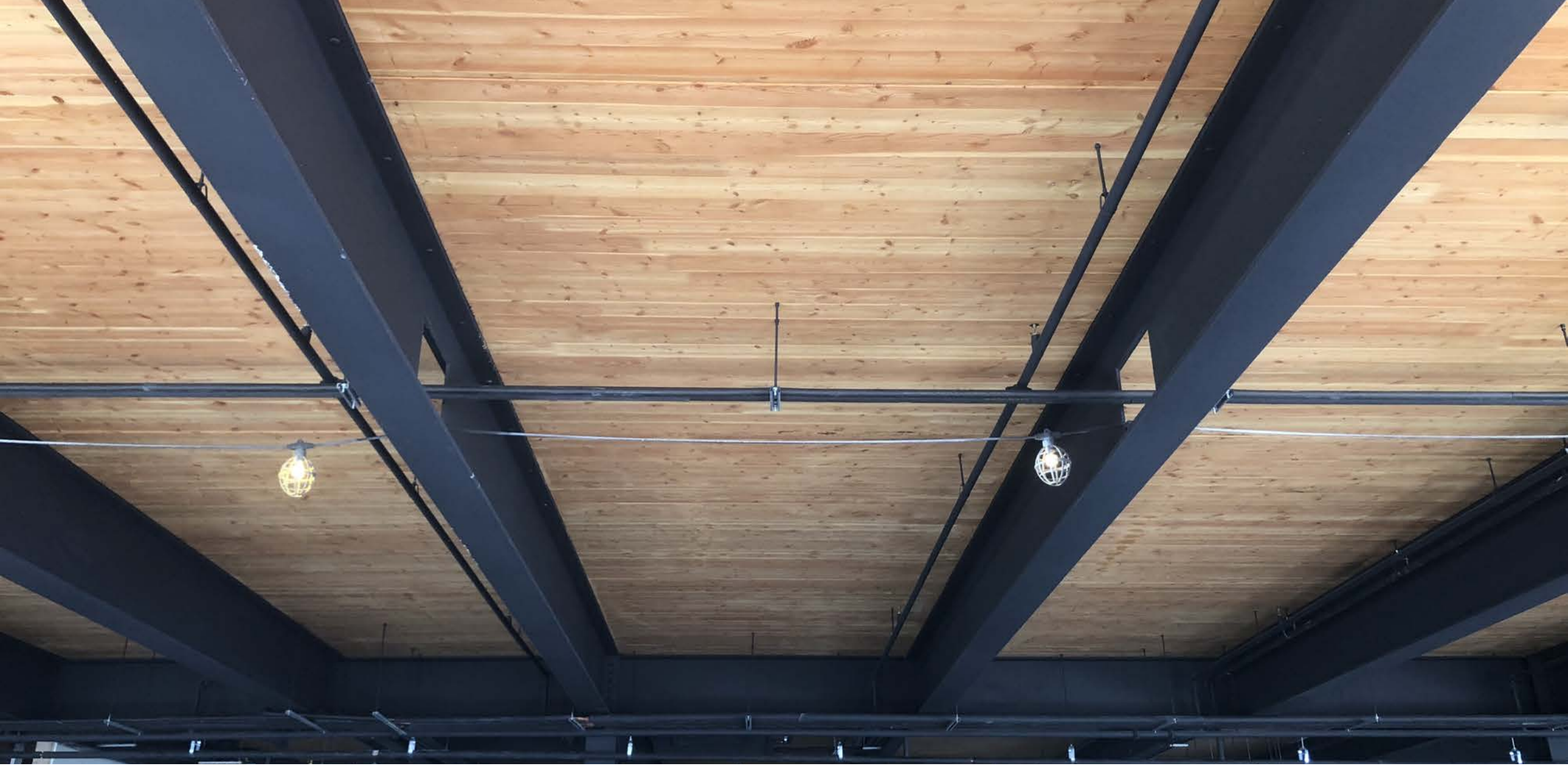
IMAGE CREDIT: BLAINE BROWNELL

STRUCTURAL SOLUTIONS | POST, BEAM + PLATE

Photo: Seagate Structures

Photo: Lendlease

STRUCTURAL SOLUTIONS | HYBRID LIGHT-FRAME + MASS TIMBER



FRAMING OPTIONS | HYBRID STEEL + MASS TIMBER

Glue Laminated Timber (Glulam)
Beams & columns

Photo: StructureCraft

Cross-Laminated Timber (CLT)
Solid sawn laminations

Photo: LendLease

Cross-Laminated Timber (CLT)
SCL laminations

Photo: Freres Lumber

Photo: LEVER Architecture

Dowel-Laminated Timber (DLT)

Photo: StructureCraft

Nail-Laminated Timber (NLT)

Photo: Think Wood

Glue-Laminated Timber (GLT)

Plank orientation

Photo: StructureCraft

Photo: StructureCraft

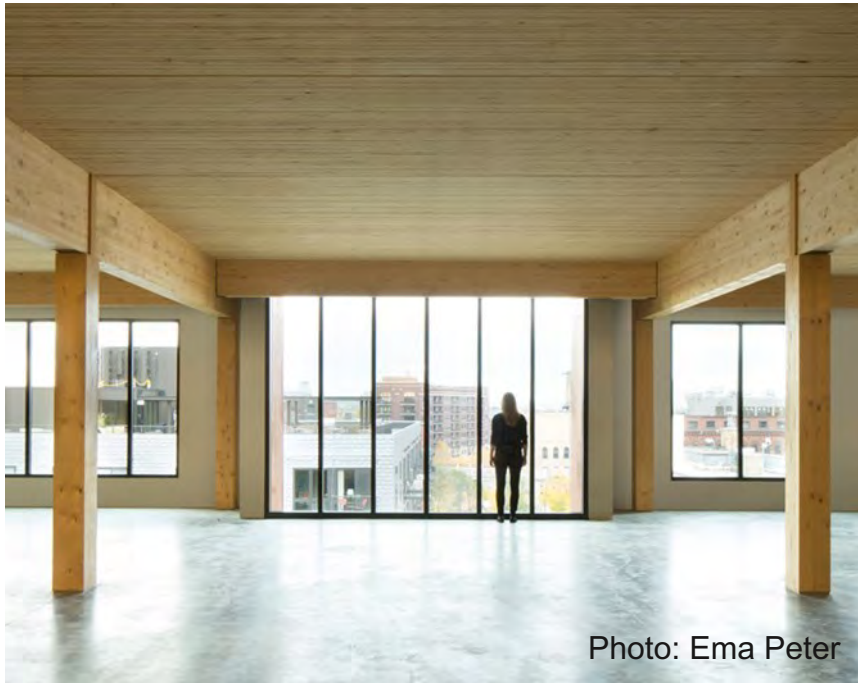
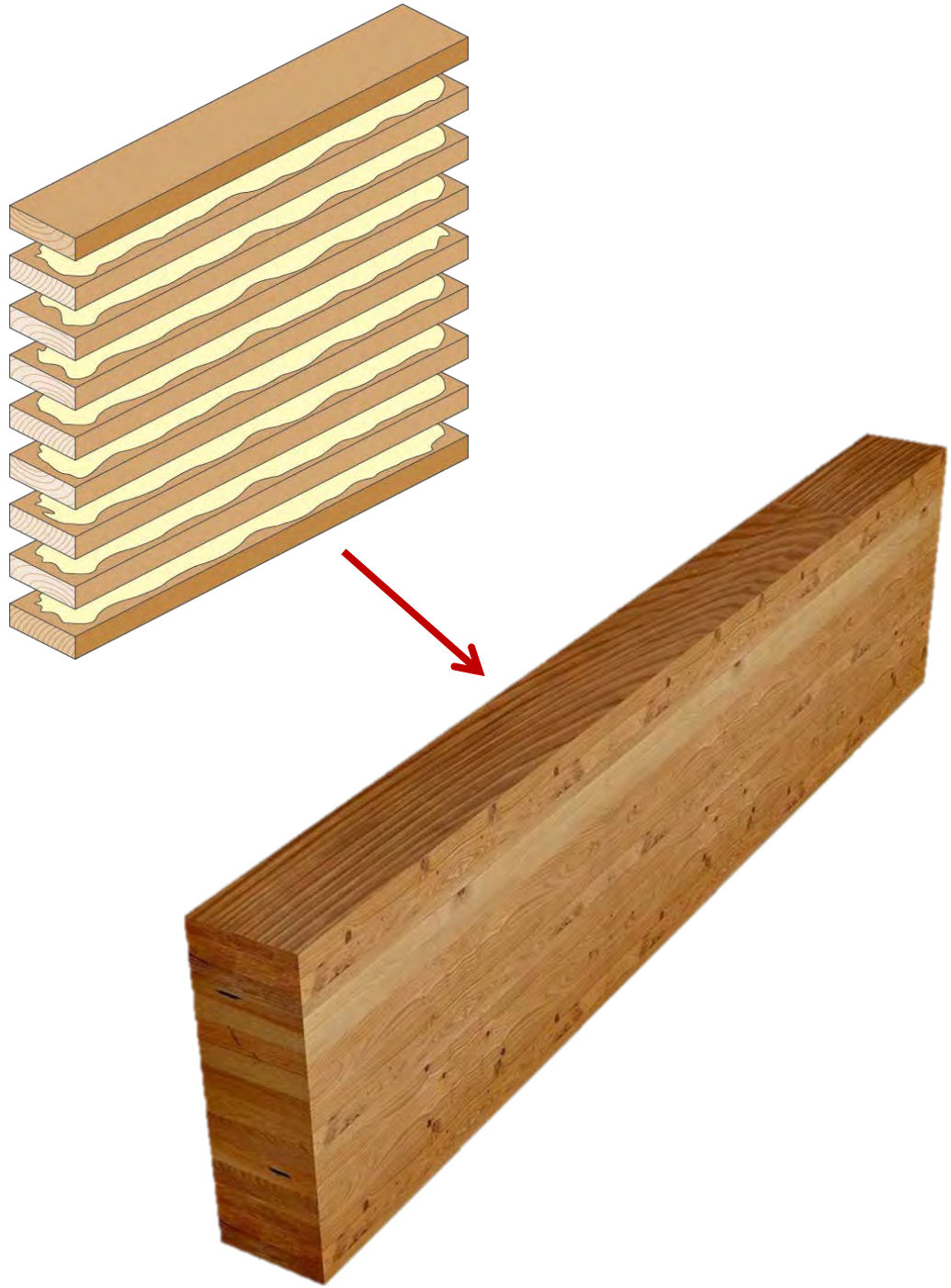


Photo: Ema Peter

Photo: Manasc Isaac Architects/Fast + Epp

Glue Laminated Timber (GLT)

Photo: Manasc Isaac Architects/Fast + Epp



Nail-Laminated Timber (NLT)

Photo: StructureCraft

Photo: Think Wood

Image Credit: Ema Peter

Dowel-Laminated Timber (DLT)

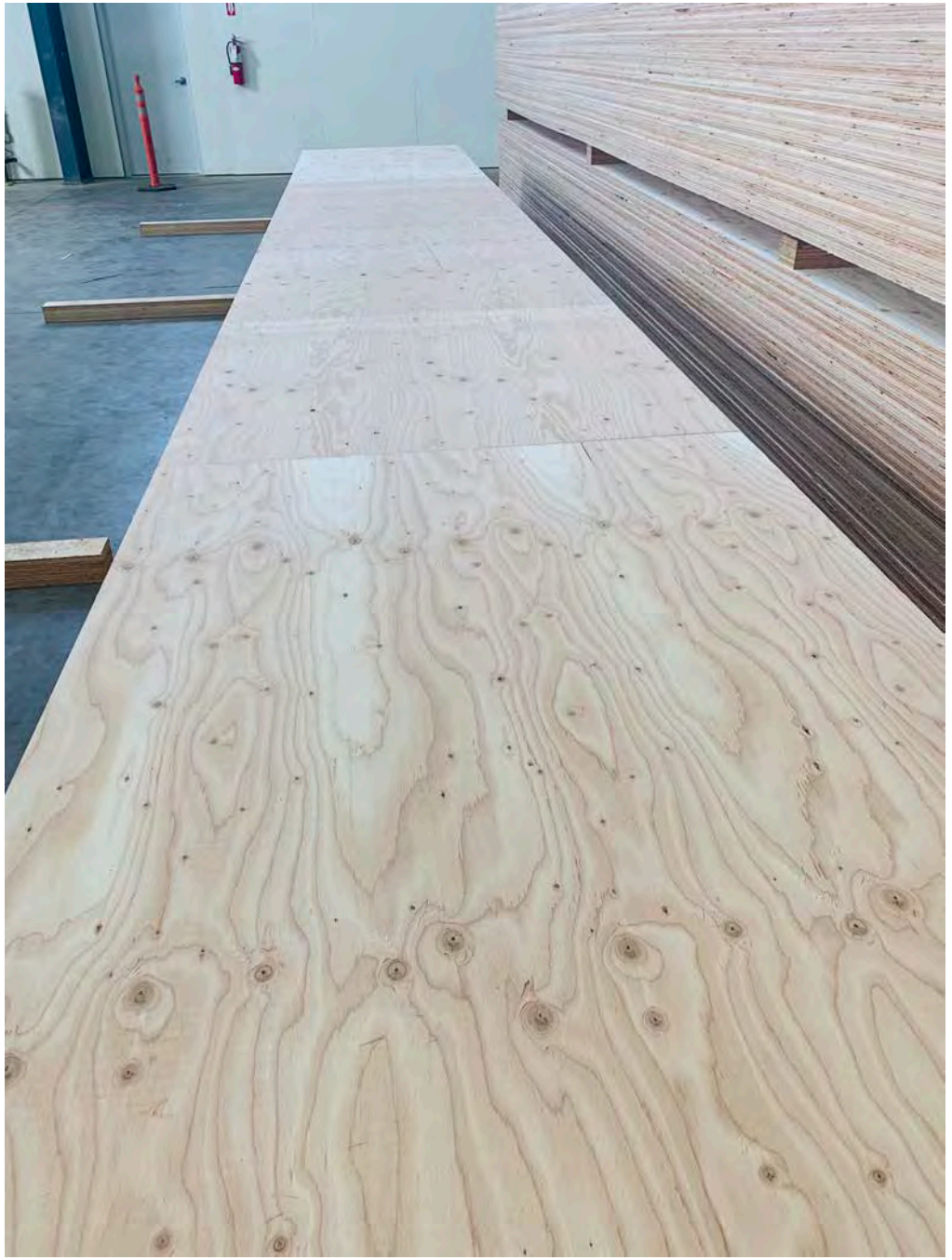
Photo: StructureCraft

Photos: StructureCraft

Photo: Hartshorne Plunkard Architecture

Cross-Laminated Timber (CLT) - Solid sawn laminations

Cross-Laminated Timber (CLT) - with SCL laminations



Photos: Freres Lumber

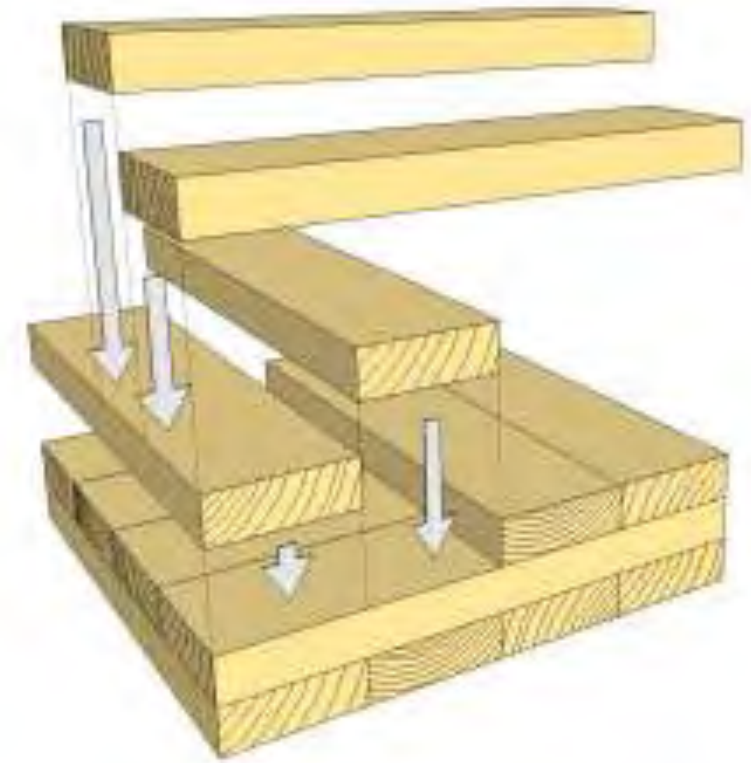
PROJECT ONE

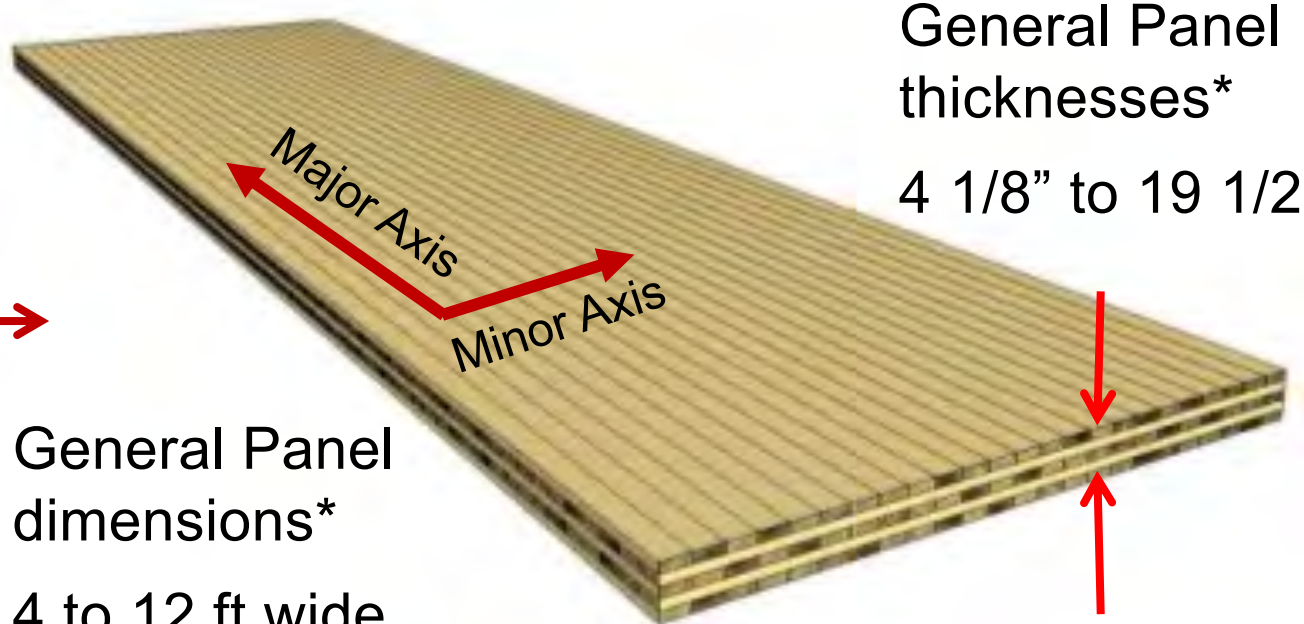
OAKLAND, CA

IMAGE CREDIT: GURNET POINT LLC

Cross-Laminated Timber (CLT)

With solid sawn laminations





General Panel thicknesses*

4 1/8” to 19 1/2”

General Panel dimensions*

4 to 12 ft wide

24 to 64 ft long

*Consult with manufacturers for available panel sizes

MASS TIMBER PRODUCTS

CLT PANEL FABRICATION

CROSS-LAMINATED TIMBER (CLT)

ALBINA YARD

PORTLAND, OR

4 STORIES
16,000 SF
GREEN ROOF

ARCHITECT: LEVER ARCHITECTURE
IMAGE CREDIT: LEVER ARCHITECTURE

ONE DE HARO

SAN FRANCISCO, CA

4 STORIES

130,000

SIGNIFICANT SAVINGS ON FOUNDATION COSTS WITH MASS TIMBER

IMAGE CREDIT: NORDIC STRUCTURES

IMAGE CREDIT: ALEX NYE

Concealed Connectors

Self Tapping Screws

Photos: Rothoblaas

MASS TIMBER DESIGN

CONNECTIONS

PHOTO CREDIT: STRUCTURECRAFT BUILDERS

PHOTO: STRUCTURLAM

PHOTO CREDIT: ALEX SCHREYER

Column to Foundation

Photo: Alex Schreyer

Panel to Panel & Supports

Photo: Charles Judd

Photo: Alex Schreyer

MASS TIMBER DESIGN

Common mass timber floor assembly:

- Finish floor (if applicable)
- Underlayment (if finish floor)
- 1.5” to 3” thick concrete/gypcrete topping
- Acoustical mat
- WSP (if applicable)
- Mass timber floor panels

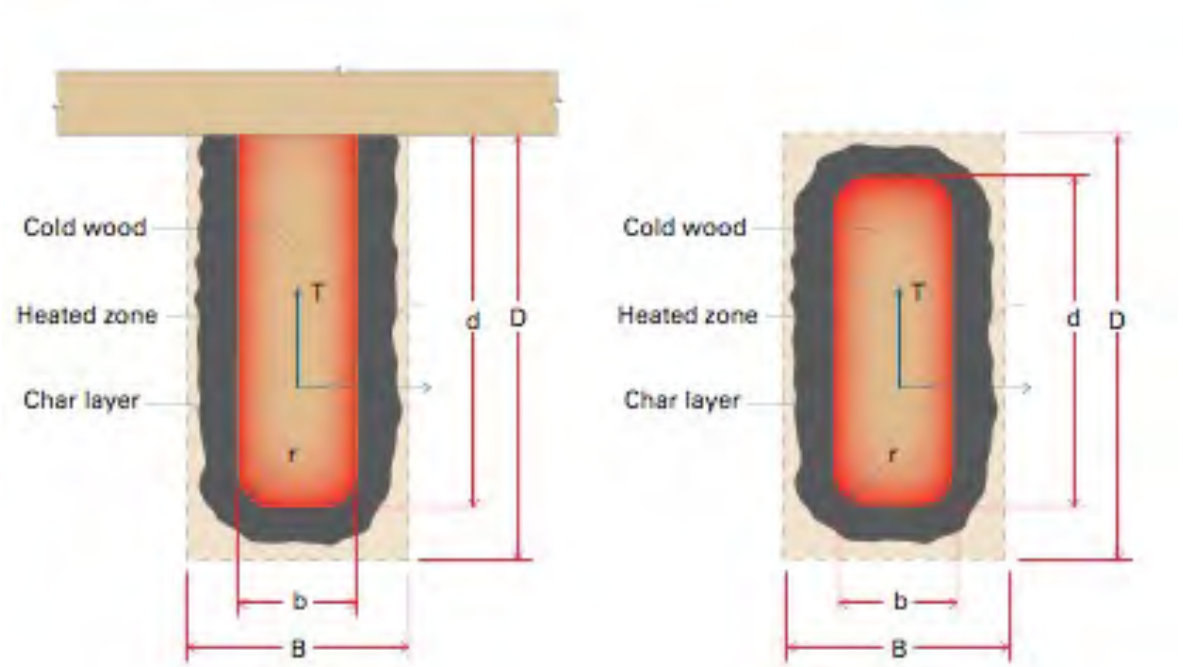
Image credit: AcoustiTECH

Mass Timber's Fire-Resistive Performance is Well-Tested, Documented and Recognized via Code Acceptance

Table 16.2.1A Char Depth and Effective Char Depth (for β_n = 1.5 in./hr.)

Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

Source: AWC's NDS

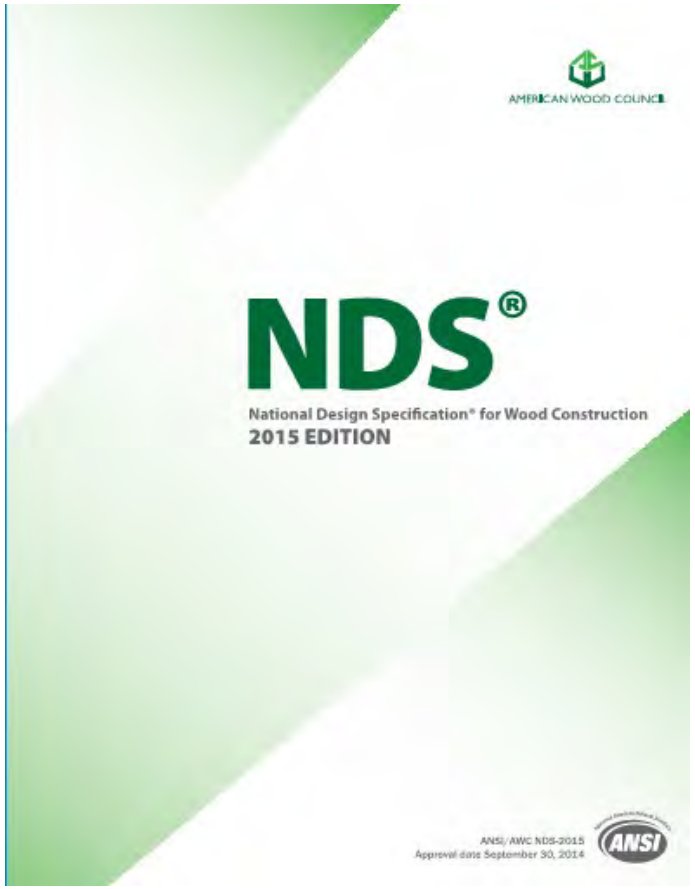


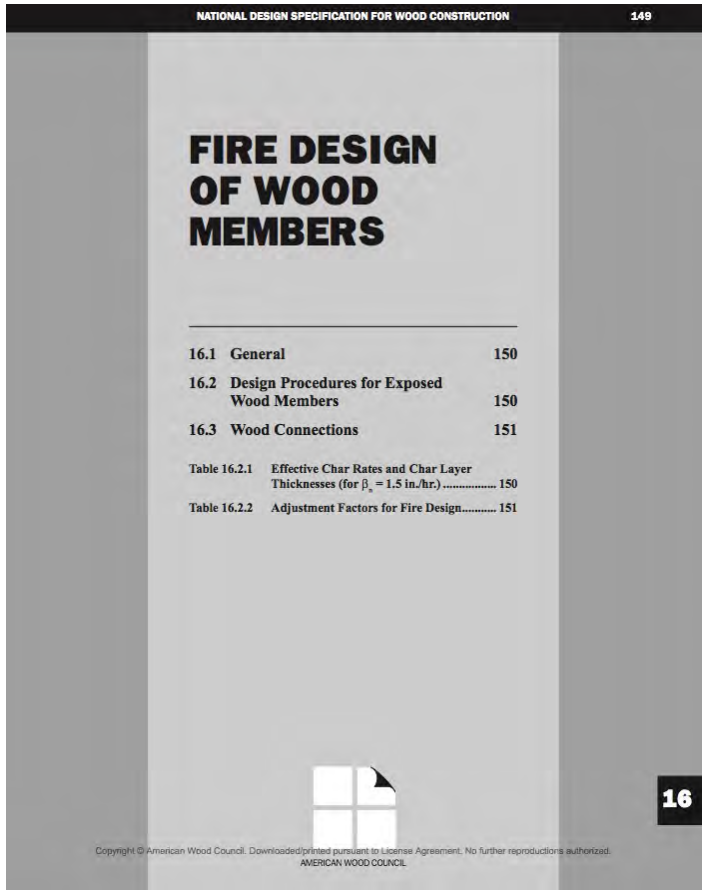
Source: AWC's TR 10

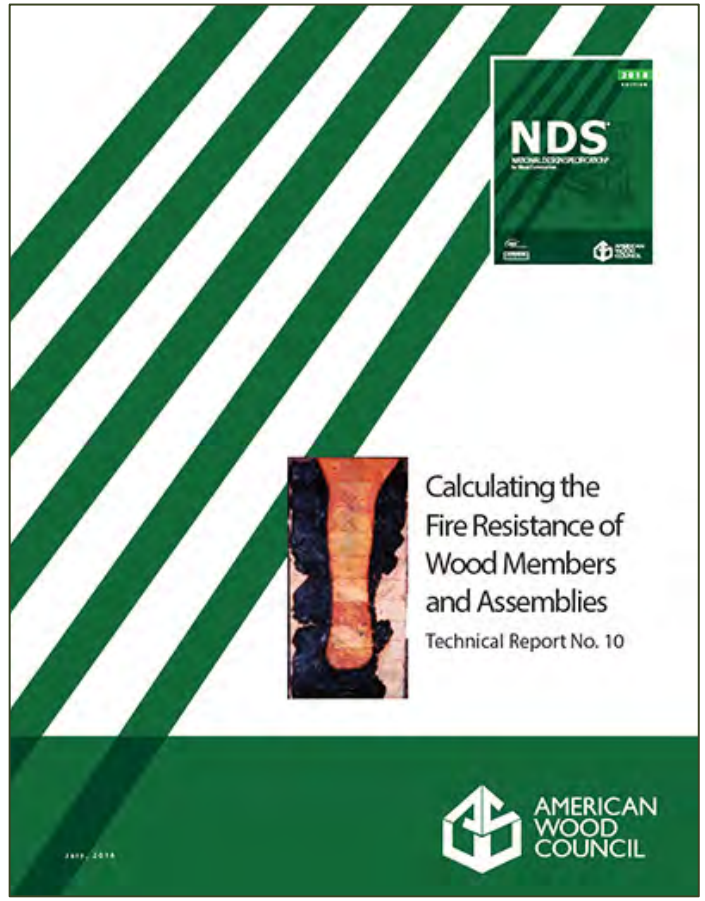
MASS TIMBER DESIGN

FIRE RESISTANCE

FOR EXPOSED WOOD MEMBERS: IBC 722.1 REFERENCES AWC'S NDS CHAPTER 16 (AWC'S TR 10 IS A DESIGN AID TO NDS CHAPTER 16)







MASS TIMBER
UNDERSTANDING THE WHY

Global Population Increase

2019 = 7.7 billion people

2050 = 11.2 billion people

Source: https://ourworldindata.org/future-population-growth

New Buildings & Greenhouse Gases

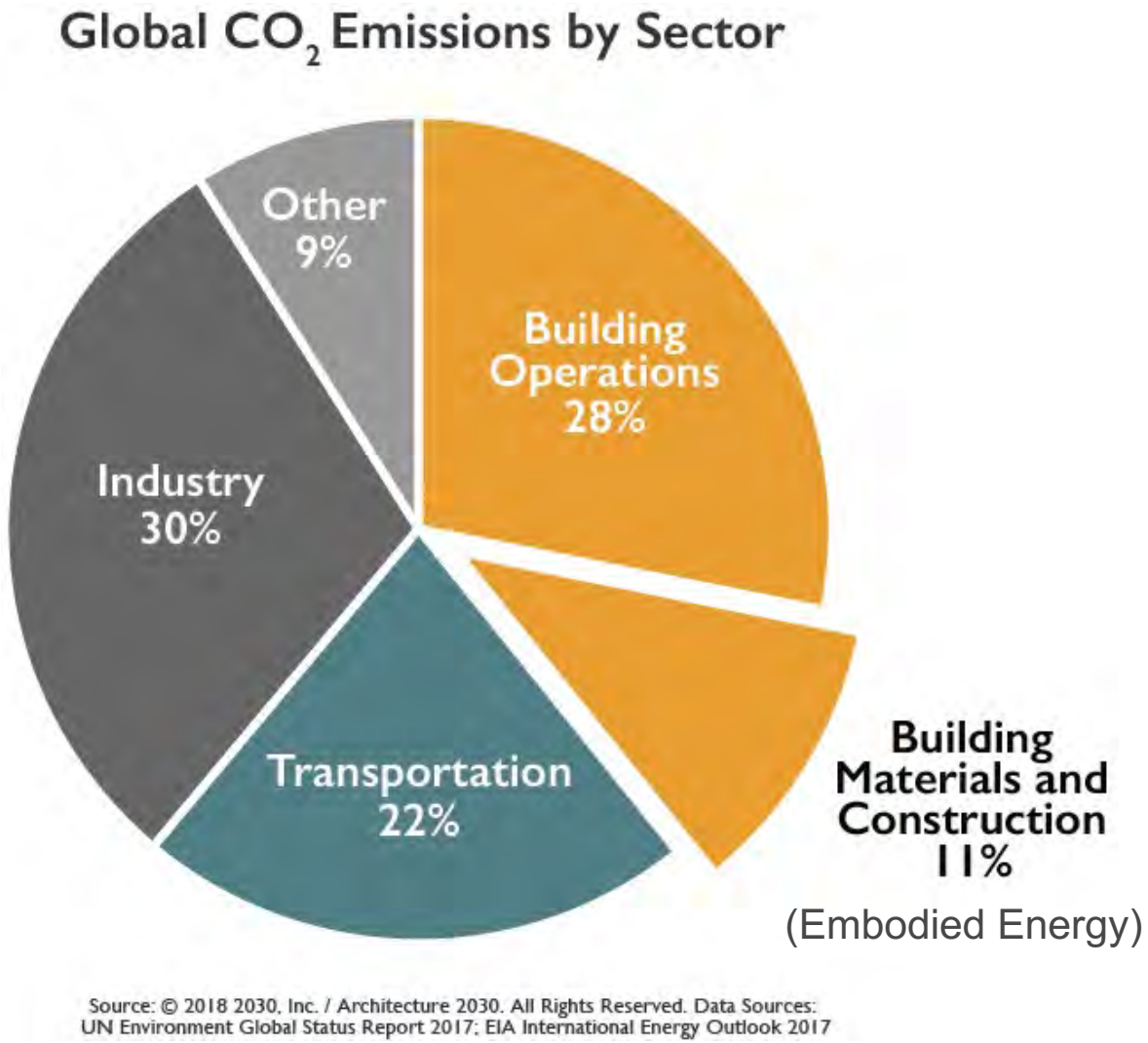


Image: Architecture 2030

Buildings generate nearly 40% of annual global greenhouse gas emissions (*building operations + embodied energy*)

Embodied Energy (11%): Concrete, iron + steel produce approximately 9% of this (Architecture 2030)

Embodied Carbon

Embodied vs. Operational Energy

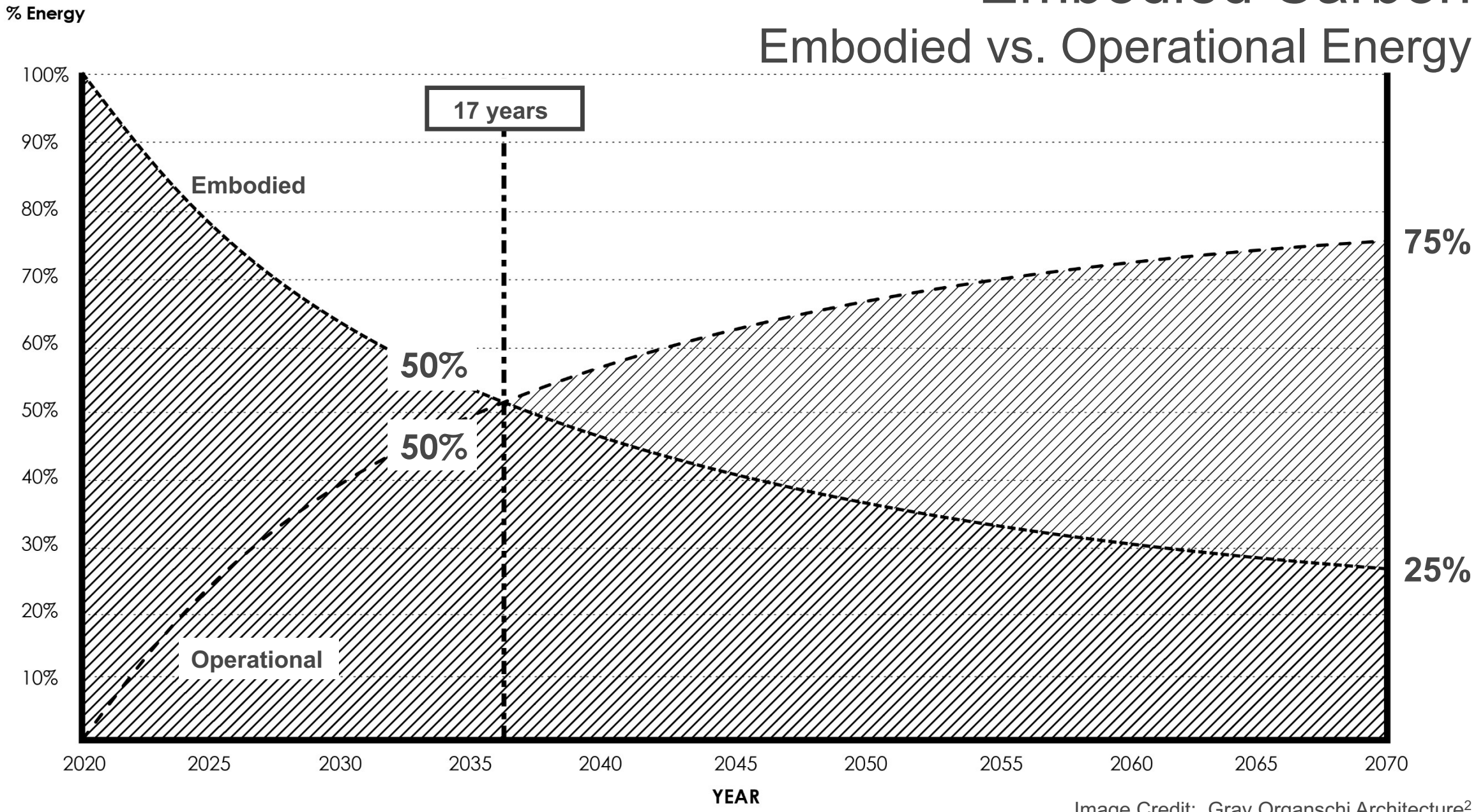


Image Credit: Gray Organschi Architecture[2]

Carbon Storage

Wood ≈ 50% Carbon (dry weight)

Image: Kaiser + Path

Image: Lever Architecture

Carbon Benefits of Wood

- **Less energy intensive** to manufacture than steel or concrete
- **Less fossil fuel consumed** during manufacture
- **Avoid process emissions**
- Carbon **storage in forests** and **promote forest health**
- Extended carbon **storage in products**

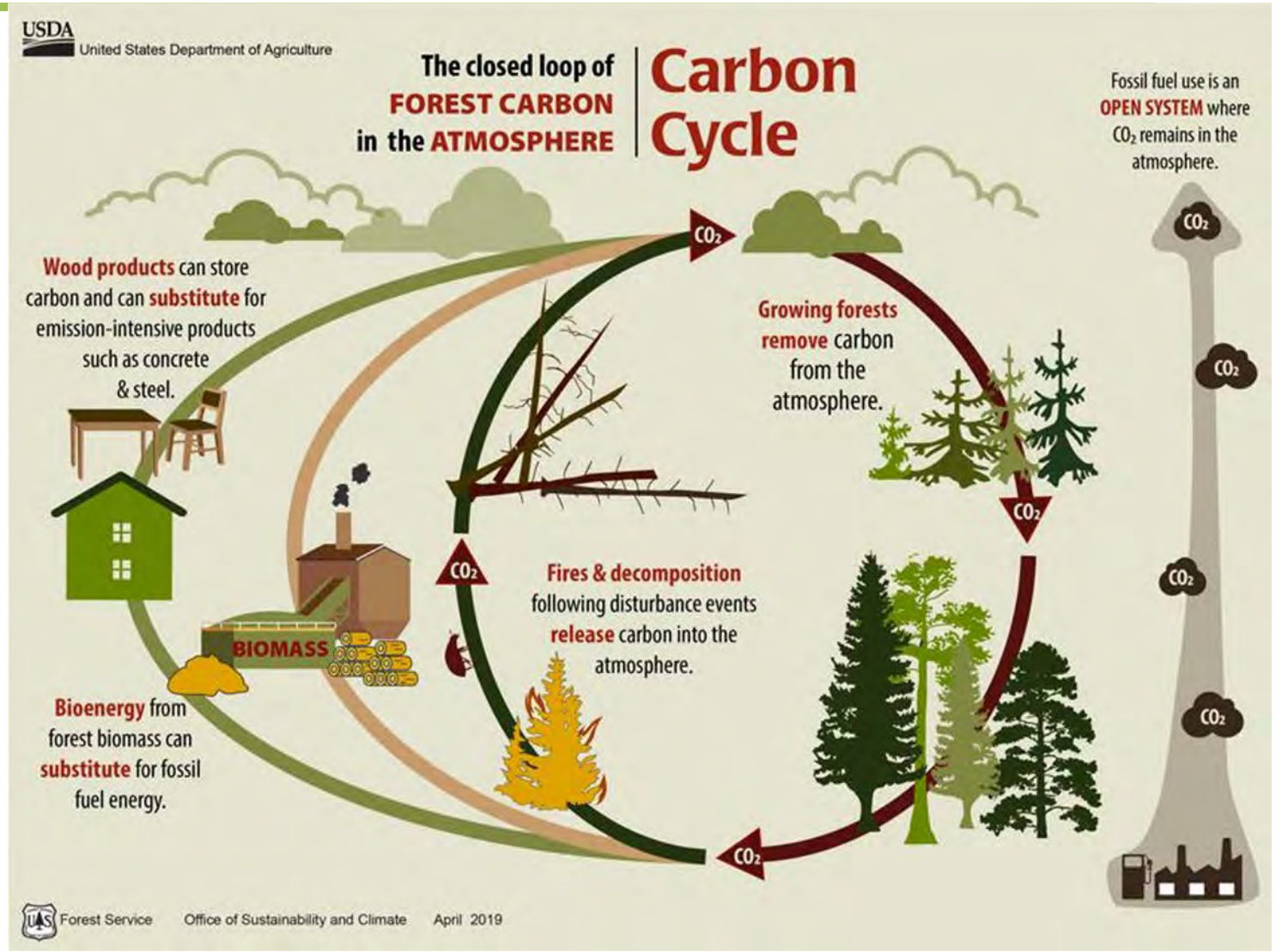


Image: USDA US Forest Service

Biophilia - Structural Warmth is a Value-Add

TMBR (unbuilt) Minneapolis, MN | Images: D/O Architects

Construction Impacts: Labor Availability

MASS TIMBER APPEAL

REDUCED CONSTRUCTION TIME

1 Floor = 3 Days

17 Floors Erected in 9.5 Weeks

Brock Commons, Vancouver, BC
Source: naturally:wood[5]

MASS TIMBER APPEAL

MATERIAL MASS

75% LIGHTER WEIGHT THAN CONCRETE

SOURCE: STRUCTURLAM[7]

MARKET DRIVERS FOR MASS TIMBER

PRIMARY DRIVERS

- Construction Efficiency & Speed
- Construction site constraints – Urban Infill
- Innovation/Aesthetic

SECONDARY DRIVERS

- Carbon Reductions
- Structural Performance – lightweight

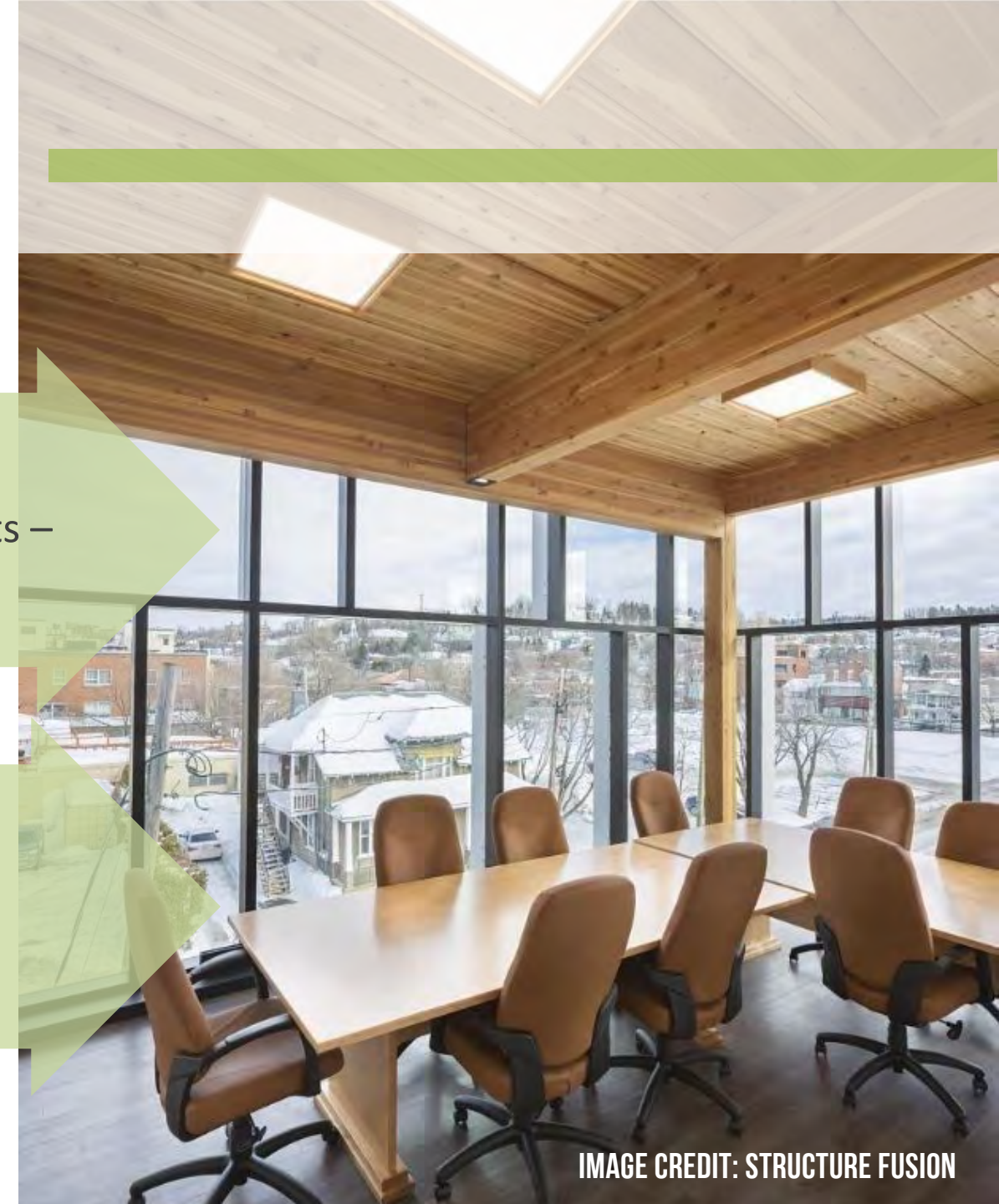


IMAGE CREDIT: STRUCTURE FUSION

Tall Wood Provisions

Presented by Mike Romanowski, SE

Photo: Kaiser+Path

Questions we'll answer:

- What is tall wood?
- How tall is tall?
- What has been done?
- What wood products are used in tall wood?
- What does the Code allow now?
- How did we arrive at the proposed tall wood code changes?
- What are the new tall wood code provisions?

Photo: Michael Green Architecture

Photos: Bygg Mesteren | Voll Arkitekter

MJOSTARNET, NORWAY

18 STORIES | 280 FT

Photos: *RLP Rüdiger Lainer + Partner, RWTplus*

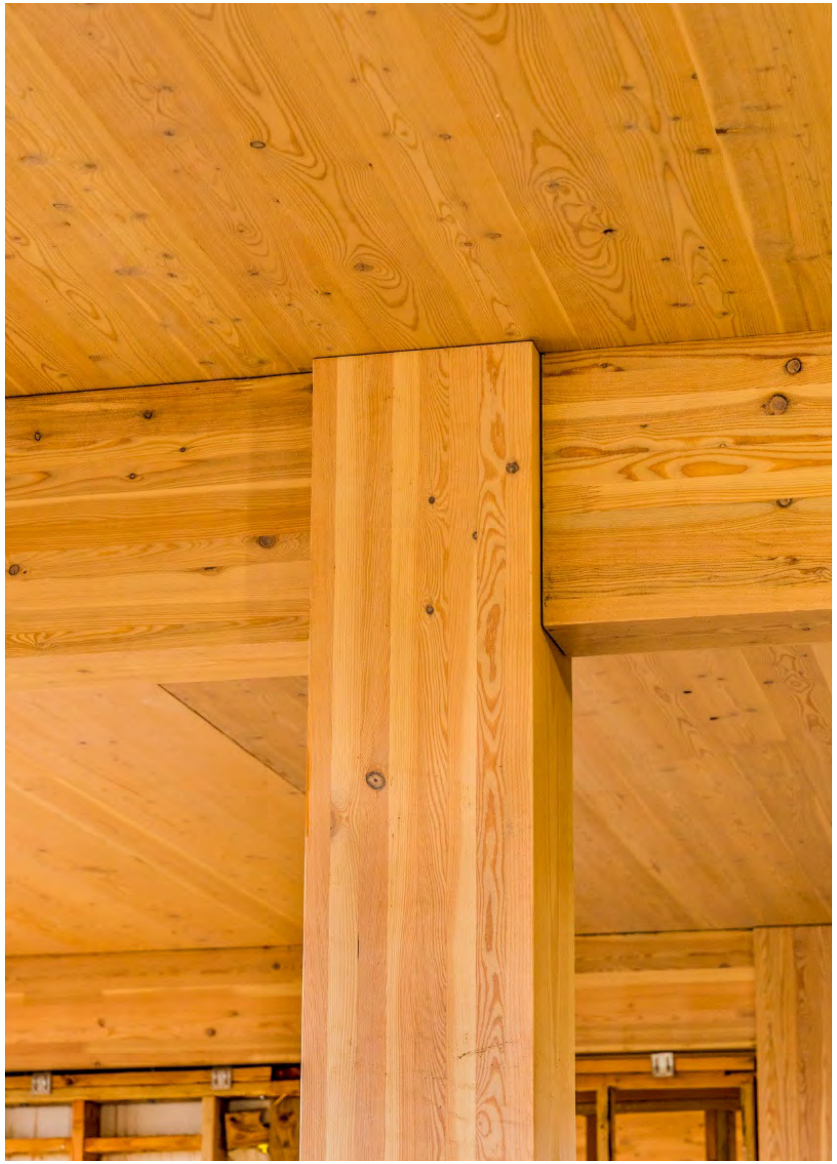
HOHO, AUSTRIA

24 STORIES | 275 FT

Photos: Michael Elkan | Naturally Wood | UBC

BROCK COMMONS, BRITISH COLUMBIA

18 STORIES | 174 FT



Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman | Architect: PATH Architecture

CARBON12, PORTLAND, OR

8 STORIES | 85 FT

ASCENT, MILWAUKEE

Photo: Korb & Associates Architects |
Architect: Korb & Associates Architects

INTRO, CLEVELAND

9 Stories | 115 ft

8 Timber Over 1 Podium

512,000 SF

297 Apartments, Mixed-Use

Photo: Harbor Bay Real Estate Advisors, Image Fiction | Architect: Hartshorne Plunkard Architecture

80 M ST, WASHINGTON, DC

3 STORY OVER-BUILD

ON EXISTING 7 STORY BUILDING

Photo: Hickok Cole | Architect: Hickok Cole

U.S. BUILDING CODE STATUS

Photo: Ema Peter

- Current Prescriptive Code Limit - 6 stories (B occupancy) or 85 feet
- Over 6 Stories - Alternate Materials and Methods Request (AMMR) through performance-based design
- Based on the 1910 Heights and Areas Act

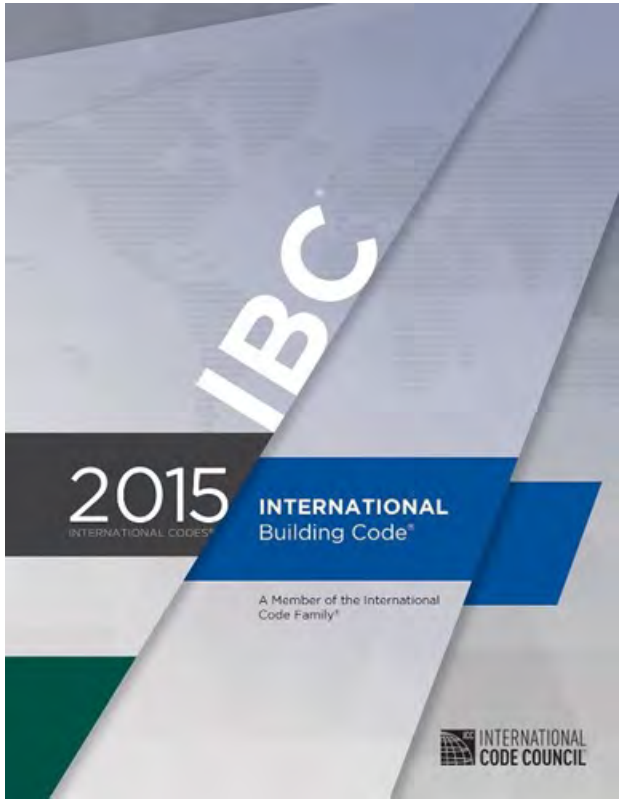
Photo: Alex Schreyer

U.S. TALL WOOD
DEVELOPMENT AND CHANGES

Seen as the catalyst for the mass timber revolution, CLT is first recognized in US codes in the 2015 IBC

[BS] CROSS-LAMINATED TIMBER. A prefabricated engineered wood product consisting of not less than three layers of solid-sawn lumber or *structural composite lumber* where the adjacent layers are cross oriented and bonded with structural adhesive to form a solid wood element.

2303.1.4 Structural glued cross-laminated timber. Cross-laminated timbers shall be manufactured and identified in accordance with ANSI/APA PRG 320.



U.S. TALL WOOD
DEVELOPMENT AND CHANGES

In December 2015, the ICC Board established the ICC Ad Hoc Committee (AHC) on Tall Wood Buildings. Objectives:

1. Explore the building science of tall wood buildings
2. Investigate the feasibility of tall wood buildings
3. Take action on developing code changes for tall wood buildings

Taller wood buildings create new set of challenges to address:

AHC established 6 performance objectives:

1. No collapse under reasonable scenarios of complete burn-out of fuel without automatic sprinkler protection being considered.
2. Highly reliable fire suppression systems to reduce the risk of failure during reasonably expected fire scenarios. The degree of reliability should be proportional to evacuation time (height) and the risk of collapse.

Performance Objectives

3. No unusually high radiation exposure from the subject building to adjoining properties to present a risk of ignition under reasonably severe fire scenarios.
4. No unusual response from typical radiation exposure from adjacent properties to present a risk of ignition of the subject building under reasonably severe fire scenarios.

Performance Objectives

5. No unusual fire department access issues.
6. Egress systems designed to protect building occupants during the design escape time, plus a factor of safety.

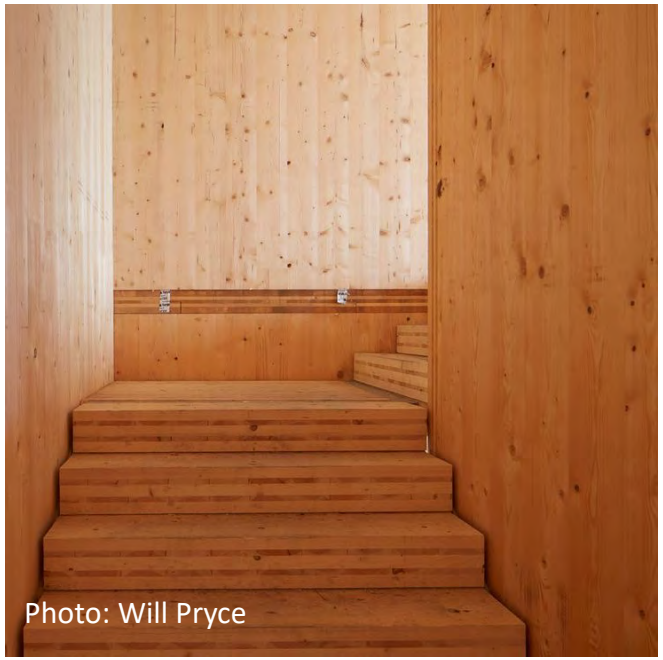


Photo: Will Pryce

U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

Commissioned series of 5 full-scale tests on 2-story mass timber structure at ATF lab in MD, May-June 2017

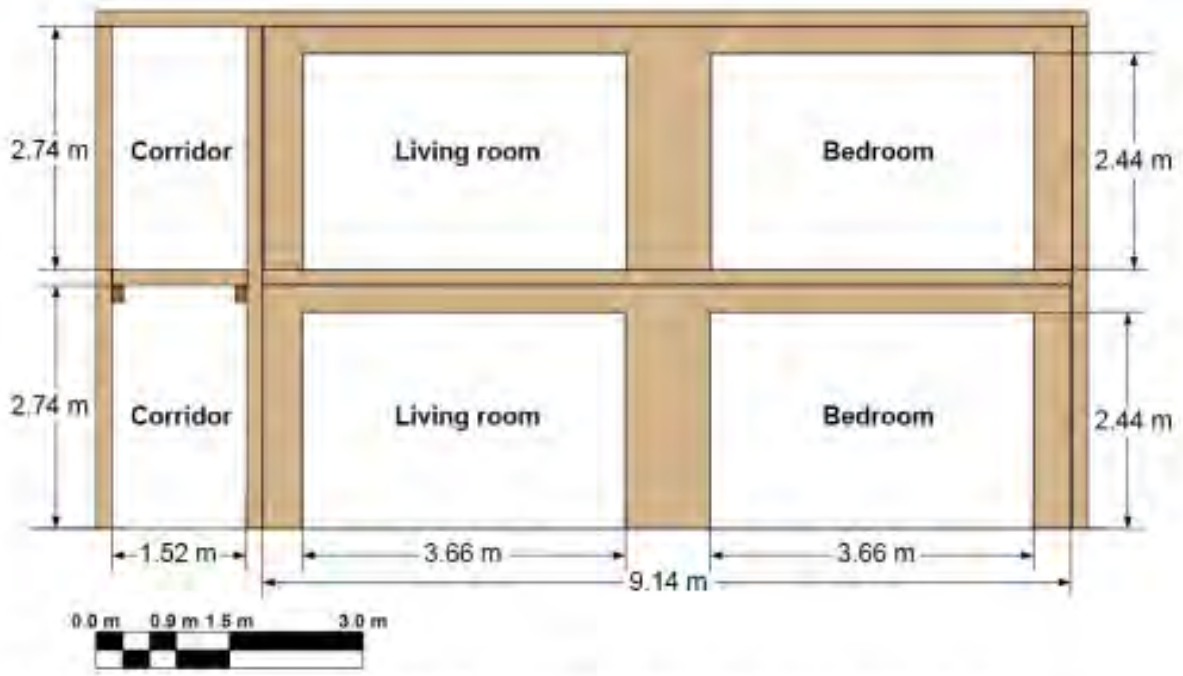


Figure 2. Elevation view of the front of the cross-laminated timber test structure.

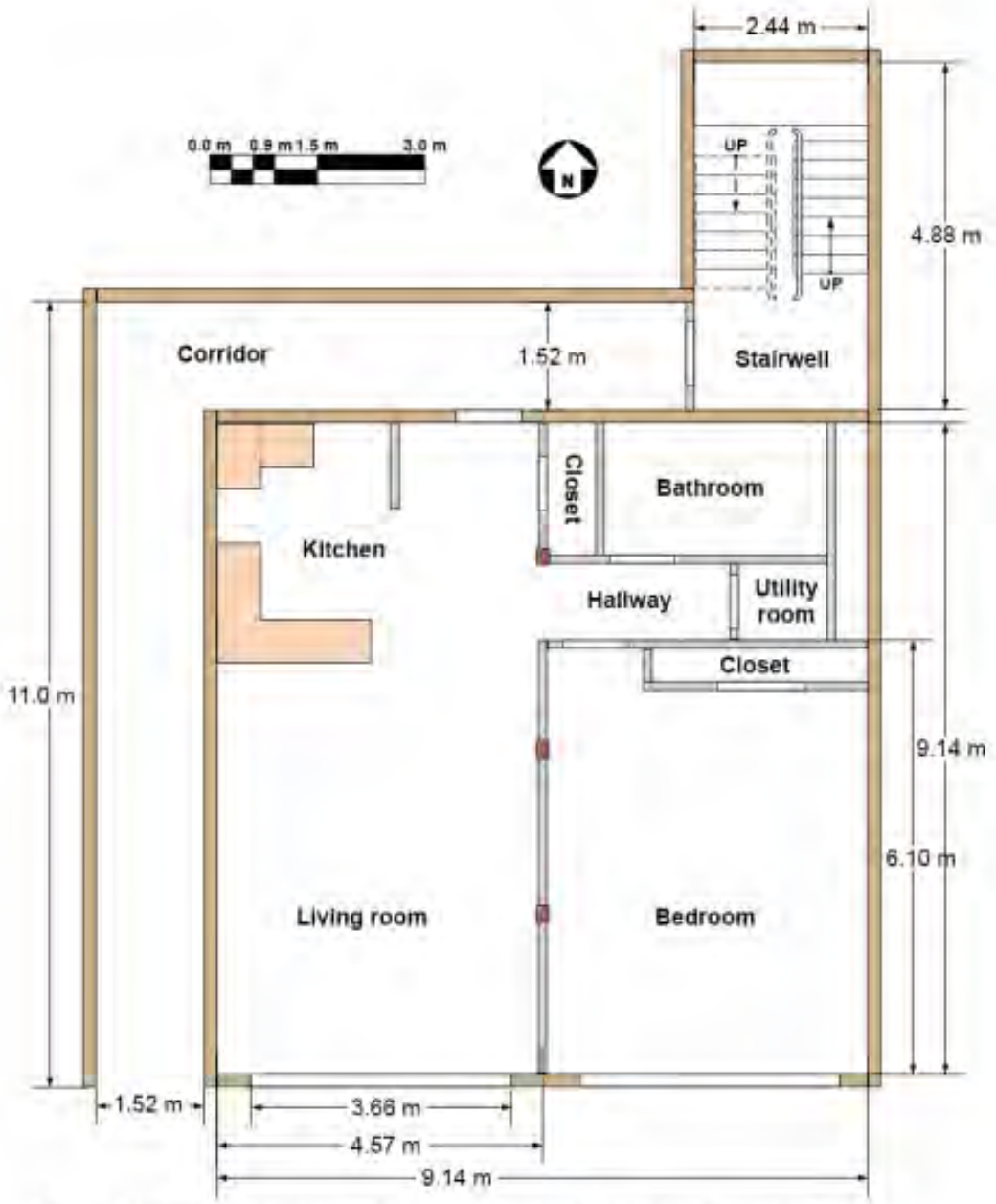


Figure 1. General plan view of cross-laminated timber test structure.

Images: AWC

Photo: LendLease

U.S. BUILDING CODES
Tall Wood Ad Hoc Committee

Test	Description	Construction Type
Test 1	All mass timber surfaces protected with 2 layers of 5/8” Type X Gypsum. No sprinklers.	IV-A
Test 2	30% of CLT ceiling area in living room and bedroom exposed. No sprinklers.	IV-B
Test 3	Two opposing CLT walls exposed – one in bedroom and one in living room. No sprinklers.	IV-B
Test 4	All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – normal activation.	IV-C
Test 5	All mass timber surfaces fully exposed in bedroom and living room. Sprinklered – 20 minute delayed activation.	IV-C

TEST 1 (100% GWB protection, no sprinklers)

Photos provided by U.S. Forest Products Laboratory, USDA

Source: AWC

TEST 2 (partial GWB protection, no sprinklers)


Ignition


Living Room / Kitchen Flashover


Bedroom Flashover


Decay Phase


Living Room Ceiling


Bedroom Ceiling

Photos provided by U.S. Forest Products Laboratory, USDA

Source: AWC

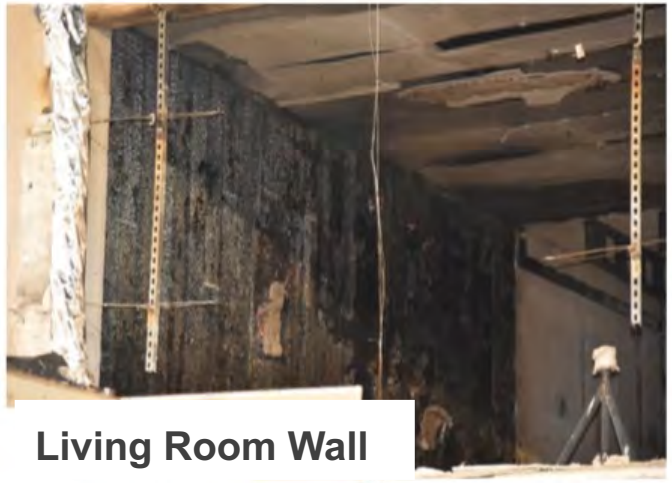
TEST 3 (partial GWB protection, no sprinklers)

Ignition

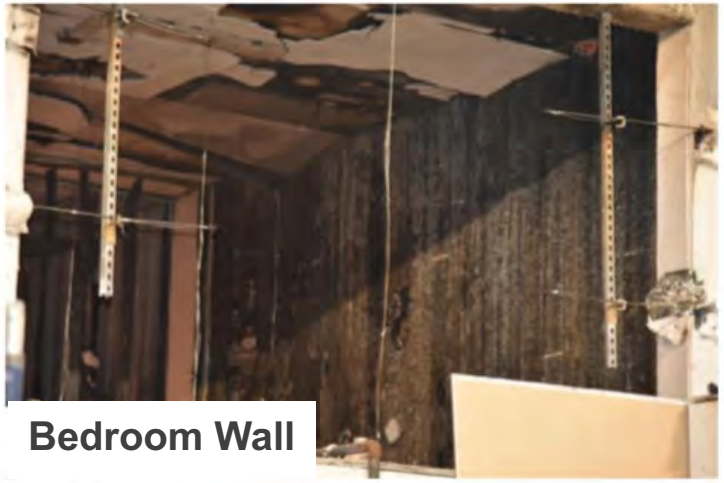
Living Room/
Kitchen Flashover

Bedroom Flashover

Decay Phase



Living Room Wall



Bedroom Wall

Photos provided by U.S. Forest Products Laboratory, USDA

Source: AWC

TEST 4

All mass timber surfaces fully exposed in bedroom and living room.

Sprinkler – normal activation

Source: AWC

Photos provided by U.S. Forest Products Laboratory, USDA

TEST 5

All mass timber surfaces fully exposed in bedroom and living room.

Sprinkler – activation delayed for 20 minutes after smoke detector activation…approximately 23-1/2 minutes from ignition

Source: AWC

Although not directly affiliated with the TWB AHC, other mass timber and tall wood testing & research was occurring, the results of which the AHC included in their final decisions

NFPA RESEARCH FOUNDATION

RESEARCH FOR THE NFPA MISSION

Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 5 – Experimental Study of Delamination of Cross Laminated (CLT) Timber in Fire

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CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

FIRE TECHNOLOGY DEPARTMENT
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FAX (210) 522-3377

NSF

DEVELOPMENT OF A FIRE PERFORMANCE ASSESSMENT METHODOLOGY FOR QUALIFYING CROSS-LAMINATED TIMBER ADHESIVES

WFCI

WESTERN FIRE CENTER, INC.

2204 Parrott Way, Kelso, Washington 98626
Phone: 360-423-1400 | Fax: 360-423-5003

Fire Resistance Testing of CLT Floor/Ceiling Assemblies to Establish Contribution of Gypsum Protection

TALL WOOD APPROVED!

Unofficial results posted Dec. 19, 2018

Final votes ratified Jan. 31, 2019

AWC: Tall Mass Timber code changes get final approval

Dec 19, 2018

LEESBURG, VA. – The International Code Council (ICC) has released the unofficial voting results on code change proposals considered in 2018, including passage of the entire package of 14 tall mass timber code change proposals. The proposals create three new types of construction (Types IV-A, IV-B and IV-C), which set fire safety requirements, and allowable heights, areas and number of stories for tall mass timber buildings. Official results are expected to be announced during the first quarter of 2019. The new provisions will be included in the 2021 *International Building Code* (IBC).

"Mass timber has been capturing the imagination of architects and developers, and the ICC result means they can now turn sketches into reality. ICC's rigorous study, testing and voting process now recognizes a strong, low-carbon alternative to traditional tall building materials used by the building

SO WHAT'S CHANGED??

ICC INTERNATIONAL CODE COUNCIL®

Since its debut, IBC has contained 9 construction type options

5 Main Types (I, II, III, IV, V) with all but IV having sub-types A and B

TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
A	B	A	B	A	B	HT	A	B

Three Main Categories:

1. Noncombustible (Types I and II)
2. Light-Frame (Types III and V)
3. **Heavy/Mass Timber (Type IV)**

Use of heavy/mass timber products in low- to mid-rise buildings of Types III and V construction is very common

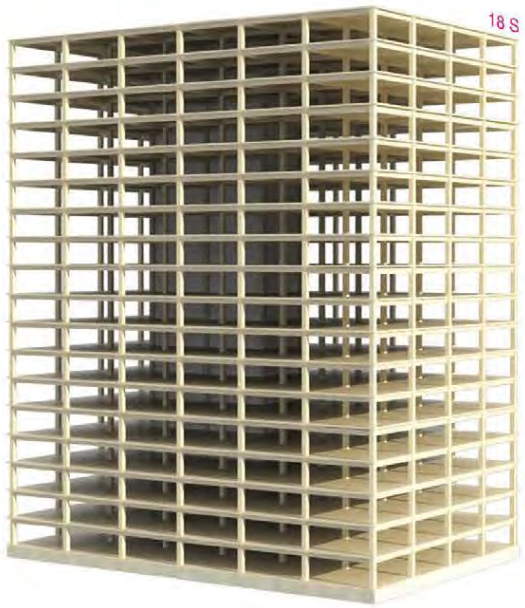
2021 IBC Introduces 3 new tall wood construction types:

IV-A, IV-B, IV-C

Previous type IV renamed type IV-HT

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B

New Building Types



18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-A

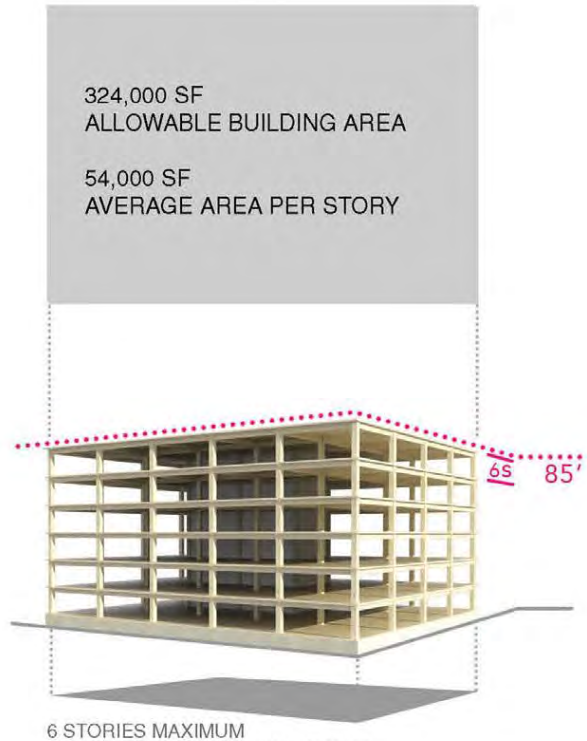
12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

9 STORIES
BUILDING HEIGHT 85'
ALLOWABLE BUILDING AREA 405,000 SF
AVERAGE AREA PER STORY 45,000 SF

TYPE IV-C

IBC 2021



6 STORIES MAXIMUM
85'-0" MAXIMUM BUILDING HEIGHT
324,00 SF MAXIMUM AREA

TYPE IV- HT

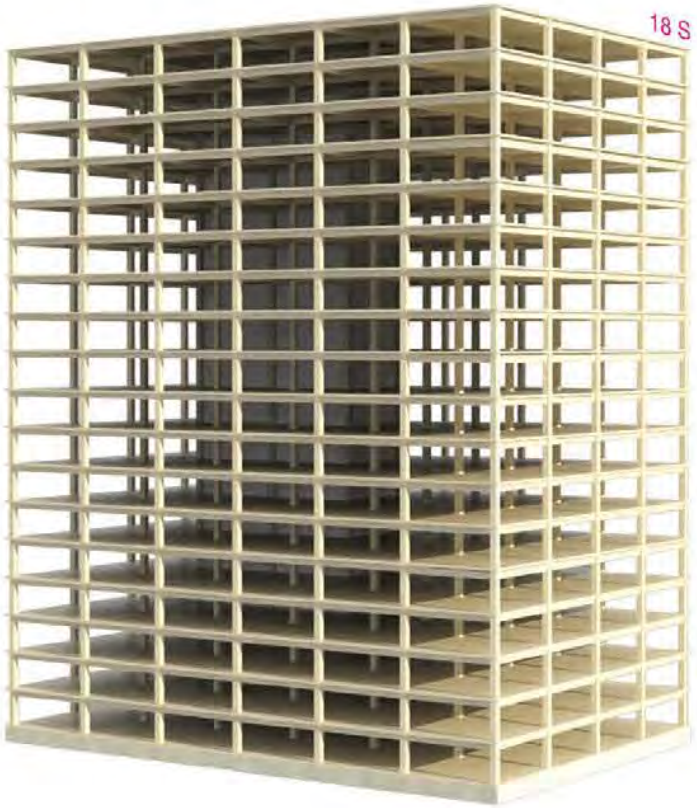
IBC 2015

BUSINESS OCCUPANCY [GROUP B]

*BUILDING FLOOR-TO-FLOOR HEIGHTS ARE SHOWN AT 12'-0" FOR ALL EXAMPLES FOR CLARITY IN COMPARISON BETWEEN 2015 TO 2021 IBC CODES.

Credit: Susan Jones, atelierjones

Type IV-A



18 STORIES

BUILDING HEIGHT	270'
ALLOWABLE BUILDING AREA	972,000 SF
AVERAGE AREA PER STORY	54,000SF

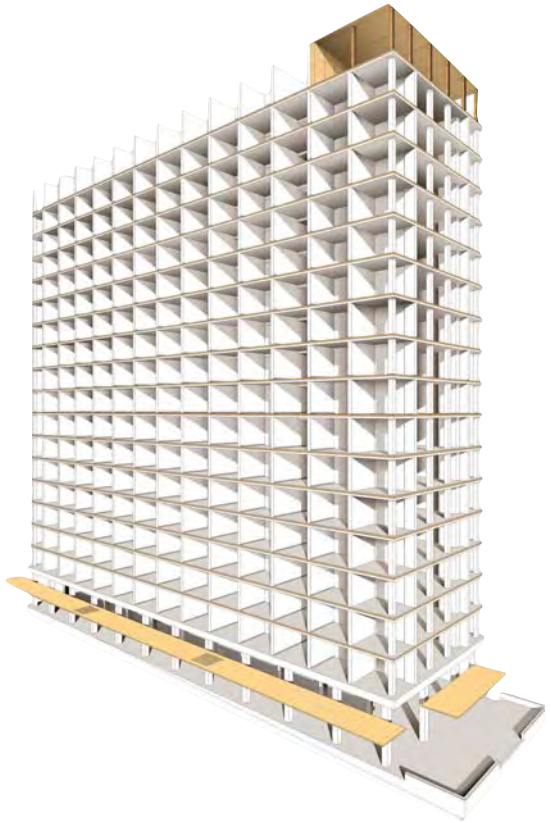
TYPE IV-A

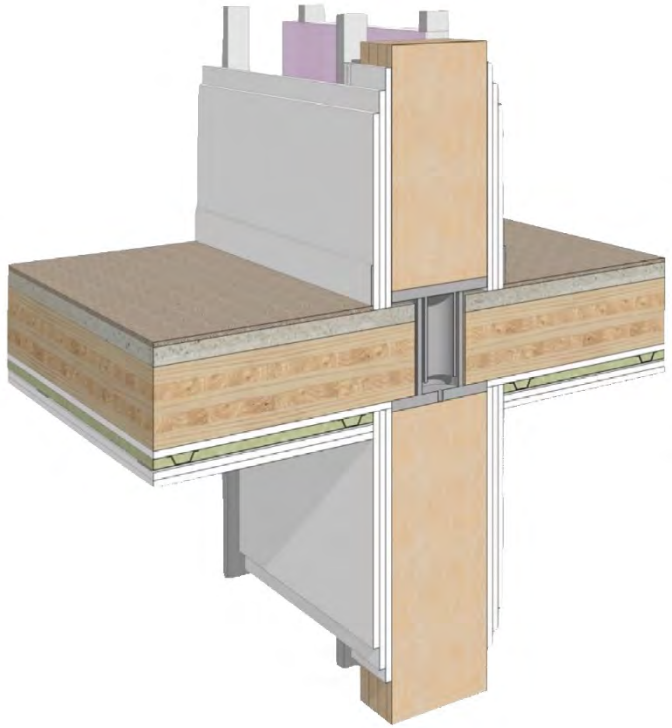
Credit: Susan Jones, atelierjones

Photos: Structurlam, naturally:wood, Fast + Epp, Urban One

Type IV-A Protection vs. Exposed

Credit: Susan Jones, atelierjones





Credit: Acton Ostry Architects, Fast + Epp

100% NC protection on all surfaces of Mass Timber

IBC Type IV-A Height and Area Limits

18 STORIES
BUILDING HEIGHT 270'
ALLOWABLE BUILDING AREA 972,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-A

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	18	270 ft	135,000 SF	405,000 SF
B	18	270 ft	324,000 SF	972,000 SF
M	12	270 ft	184,500 SF	553,500 SF
R-2	18	270 ft	184,500 SF	553,500 SF

Areas exclude potential frontage increase

In most cases, Type IV-A height & story allowances = 1.5 × Type I-B height & story allowances

Type IV-A area = 3 × Type IV-HT area

Type IV-B

12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

Credit: Susan Jones, atelierjones

Credit: LEVER Architecture

Type IV-B Protection vs. Exposed

12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

Credit: Susan Jones, atelierjones

Credit: Kaiser+Path

NC protection on all surfaces of Mass Timber except limited exposed areas

≈20% of ceiling or ≈40% of wall can be exposed, see code for requirements

IBC Type IV-B Height and Area Limits

12 STORIES
BUILDING HEIGHT 180 FT
ALLOWABLE BUILDING AREA 648,000 SF
AVERAGE AREA PER STORY 54,000SF

TYPE IV-B

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	12	180 ft	90,000 SF	270,000 SF
B	12	180 ft	216,000 SF	648,000 SF
M	8	180 ft	123,000 SF	369,000 SF
R-2	12	180 ft	123,000 SF	369,000 SF

Areas exclude potential frontage increase

In most cases, Type IV-B height & story allowances = Type I-B height & story allowances

Type IV-B area = 2 × Type IV-HT area

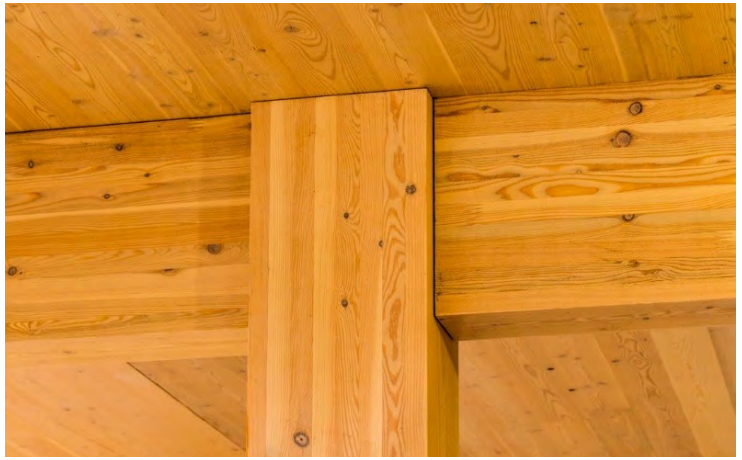
Credit: Susan Jones, atelierjones

Type IV-C

9 STORIES
BUILDING HEIGHT 85'
ALLOWABLE BUILDING AREA 405,000 SF
AVERAGE AREA PER STORY 45,000 SF

TYPE IV-C

Credit: Susan Jones, atelierjones



Photos: Baumberger Studio/PATH Architecture/Marcus Kauffman

Type IV-C Protection vs. Exposed

Credit: Susan Jones, atelierjones

Credit: Kaiser+Path, Ema Peter

All Mass Timber surfaces may be exposed

Exceptions: Shafts, concealed spaces, outside face of exterior walls

IBC Type IV-C Height and Area Limits

Occupancy	# of Stories	Height	Area per Story	Building Area
A-2	6	85 ft	56,250 SF	168,750 SF
B	9	85 ft	135,000 SF	405,000 SF
M	6	85 ft	76,875 SF	230,625 SF
R-2	8	85 ft	76,875 SF	230,625 SF

Areas exclude potential frontage increase

In most cases, Type IV-C height allowances = Type IV-HT height allowances, but add.'l stories permitted due to enhanced FRR

Type IV-C area = 1.25 × Type IV-HT area

Credit: Susan Jones, atelierjones

Tall Wood Fire Resistance Ratings (FRR)

	IV-A	IV-B	IV-C
Primary Frame or Brg Wall FRR	3 HR (2 HR at Roof)	2 HR (1 HR at Roof)	2 HR (1 HR at Roof)
Floor Construction FRR	2 HR	2 HR	2 HR
Roof Construction FRR	1.5 HR	1 HR	1 HR
Floor Surface Protection	1 inch of NC protection on top	1 inch of NC protection on top	No protection req.'d
Roof Construction Protection	2 layers 5/8" Type X gyp. on underside	2 layers 5/8" Type X gyp. on underside	No protection req.'d unless concealed space

Tall Wood Materials & Protection

	IV-A	IV-B	IV-C
Exterior Walls	If Mass Timber, exterior surface protected with 1 layer 5/8” Type X gyp.		
Structural Materials	Mass Timber or NC		
Concealed Spaces	Permitted, requires NC protection on MT surfaces		
Gypsum Protection	All MT is protected 3 HR: 3 layers 5/8” Type X gyp. 2 HR or less: 2 layers 5/8” Type X gyp.	Same as IV-A for protected MT. Limited exposed MT permitted, FRR still applies	All MT permitted may be exposed except as noted

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Tall Wood Buildings in the 2021 IBC
Up to 18 Stories of Mass Timber

Scott Breneman, PhD, SE, WoodWorks – Wood Products Council • Matt Timmers, SE, John A. Martin & Associates • Dennis Richardson, PE, CBO, CASp, American Wood Council

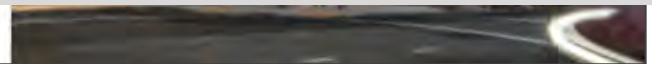
In January 2019, the International Code Council (ICC) approved a set of proposals to allow tall wood buildings as part of the 2021 International Building Code (IBC). Based on these proposals, the 2021 IBC will include three new construction types—Type IV-A, IV-B and IV-C—allowing the use of mass timber or noncombustible materials. These new types are based on the previous Heavy Timber construction type (renamed Type IV-HT) but with additional fire-resistance ratings and levels of required noncombustible protection. The code will include provisions for up to 18 stories of Type IV-A construction for Business and Residential Occupancies.

Based on information first published in the Structural Engineers Association of California (SEAOC) 2018 Conference Proceedings, this paper summarizes the background to these proposals, technical research that supported their adoption, and resulting changes to the IBC and product-specific standards.

Background: ICC Tall Wood Building Ad Hoc Committee

Over the past 10 years, there has been a growing interest in tall buildings constructed from mass timber materials (Breneman 2013, Timmers 2015). Around the world there

Via Cenni	Milan, Italy	9	2013



WoodWorks Tall Wood Design Resource

http://www.woodworks.org/wp-content/uploads/wood_solution_paper-TALL-WOOD.pdf

EARLY TALL WOOD CODE ADOPTION IN CALIFORNIA

California Building Standards Commission Passes Tall Wood Code Change Proposals

Source: Softwood Lumber Boa

On August 13, 2020 the California Building Standards Commission grouped the tall wood code change proposals into one agenda item and passed them unanimously.

The changes were published as an amendment to the 2019 CBC on January 1, 2021 and will become effective on July 1, 2021.

California Building Standards Commission Passes Tall Wood Code Change Proposals

Source: Softwood Lumber Boa

"The early adoption of mass timber codes can be a benefit to California in many ways, but I would like to highlight three of those advantages in this proposal.

1. *It has the potential to increase the market demand for mass timber production in California to meet the needs of the construction industry.*
2. *It will increase the pace and scale of our wildland fire prevention and forest management goals of treating 500 thousand acres per year by thinning the forest of smaller diameter trees that can be used in the production of cross laminated timber and other mass timber assemblies.*
3. *While wood products provide the benefit of storing carbon, another benefit or advantage is that mass timber construction can also help reduce the carbon footprint of concrete and steel production."*

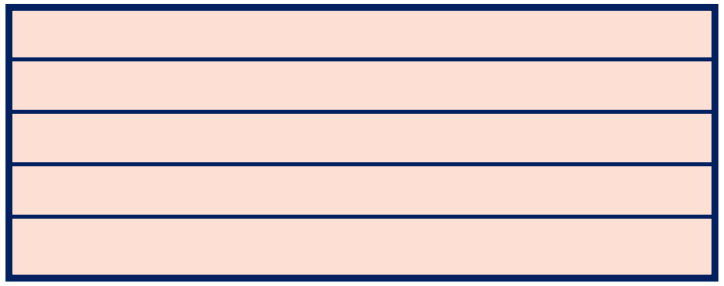
– Chief Mike Richwine, State Fire Marshal

CBC Tall Wood Building Size Limits

The CBC has historically not allowed “double-dipping” for sprinkler increases of building height and area for A, E, H, I, L or R occupancies. The IBC has no such restriction.

Also specific to the CBC, for multi-story buildings that are A, E, H, I, L or R occupancies, the total allowable building area is equal to the allowable floor area multiplied by the number of stories, not to exceed 2. In the IBC, this value is 3 for all occupancies.

This is also the case for Tall Wood.



Larger Area

VS.

Taller

CBC Tall Wood Building Size Limits

	Construction Type (Sprinklered Values)						
	I-A	I-B	IV-A	IV-B	IV-C	IV-HT	III-A
Occupancies	**Allowable Building Height above Grade Plane, Feet (CBC Table 504.3)**						
B, F, M, S, U, R-3, R-4	Unlimited	180*	270	180	85	85	85
A, E, R-1, R-2 (w/ area increase)	Unlimited	180 (160)	270 (250)	180 (160)	85 (65)	85 (65)	85 (65)
	Allowable Number of Stories above Grade Plane (CBC Table 504.4)						
A-2, A-3, A-4 (w/ area increase)	Unlimited	12 (11)	18 (17)	12 (11)	6 (5)	4 (3)	4 (3)
B	Unlimited	12	18	12	9	6	6
R-1, R-2 (w/ area increase)	Unlimited	12 (11)	18 (17)	12 (11)	8 (7)	5 (4)	5 (4)
	Allowable Area Factor (At) for SM, Feet^2 (CBC Table 506.2)						
A-1, A-2, A-3, A-4 (w/ height increase)	Unlimited	Unlimited	135,000 (45,000)	90,000 (30,000)	56,250 (18,750)	45,000 (15,000)	42,000 (14,000)
B	Unlimited	Unlimited	324,000	216,000	135,000	108,000	85,500
R-1, R-2 (w/ height increase)	Unlimited	Unlimited	184,500 (61,500)	123,000 (41,000)	76,875 (25,625)	61,500 (20,500)	72,000 (24,000)

MASS TIMBER CONSTRUCTION MANAGEMENT

Construction Management Program
2021 Program Expansion and Beyond

WoodWorks™
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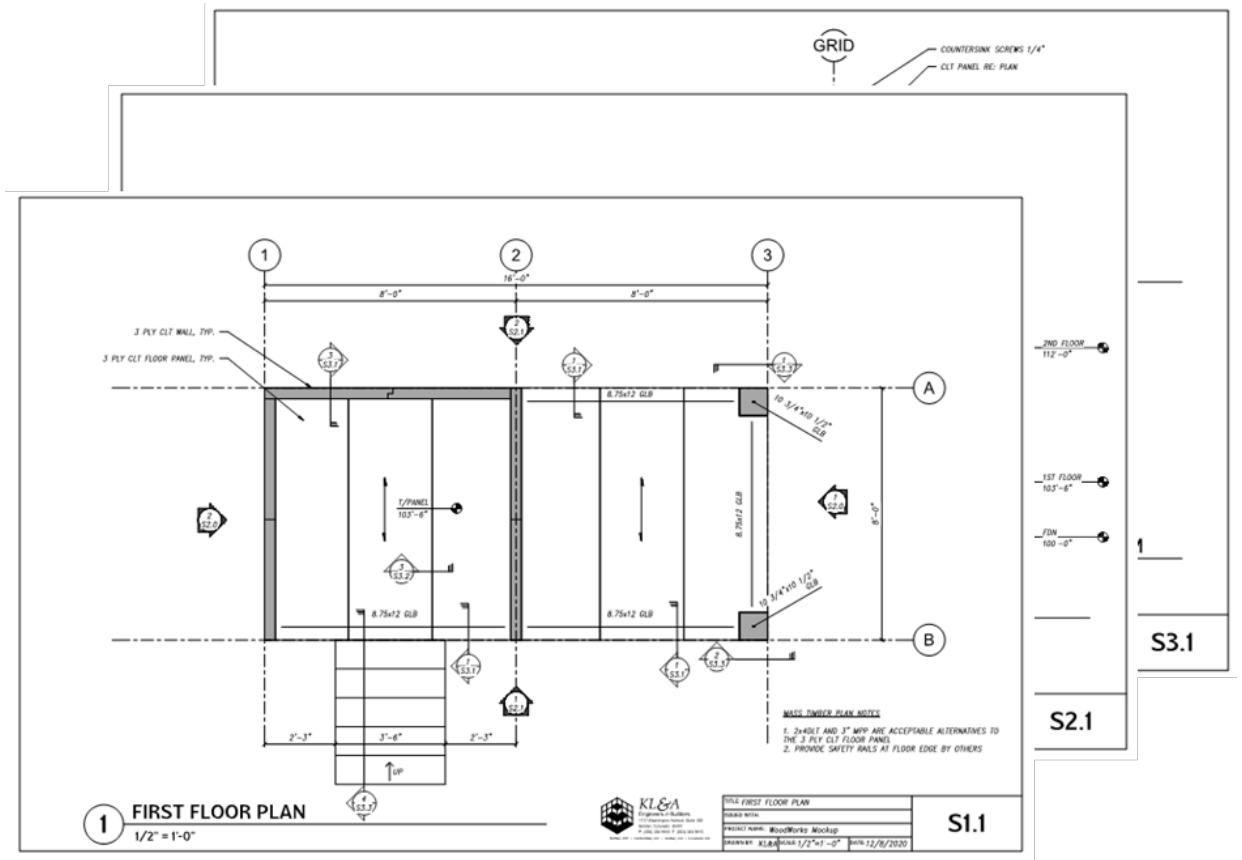
In Progress/Development

- MASS TIMBER CONSTRUCTION MANUAL
- INSTALLER TRAINING PACKAGES AND TRAINING CENTER COLLABORATION
- VIRTUAL AND/OR IN-PERSON WORKSHOPS

In Planning

- ENGAGE WITH GENERAL CONTRACTORS
- COMMUNITY COLLEGES
- PARTNER WITH CONSTRUCTION ASSOCIATIONS



Woodworks Standard Mock-Up Drawings

Photo Credit: WoodWorks

https://www.woodworks.org/mass-timber-construction-management-program

MASS TIMBER | TRAINING THE WORKFORCE

Mass Timber Construction Management

THREE KEY POINTS:

1. Mass timber is a custom building system, not a commodity.
2. Select the right partners for your project, the earlier the better.
3. Assess projects holistically when estimating costs.

Holistic cost estimation to understand value of the whole building

$/SF

$/SF

Image: GBD Architects

Total Project Cost Analysis

CONSIDERATIONS:

- Ceiling Treatment
- Floor Topping
- HVAC System & Route
- Foundation Size
- Soil Improvements
- Exterior Skin Coordination
- Value of Time

Credit: Hacker Architects

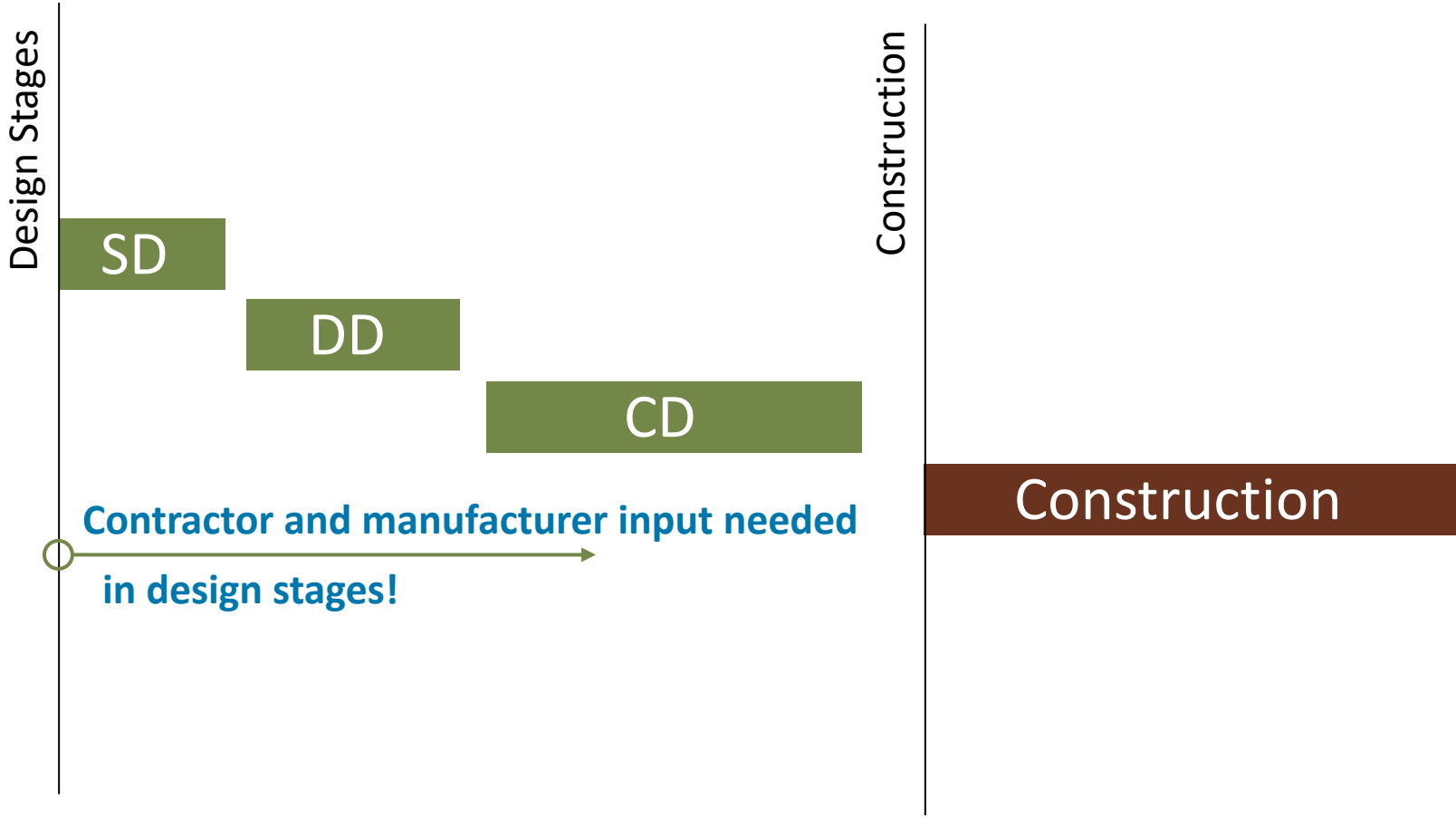
Contractual Considerations

Avoid:

- Design-bid-build

Consider:

- Design-assist
- Design-build



Embrace the Prefab Advantage

- Speed of construction
- Safety
- Quality control

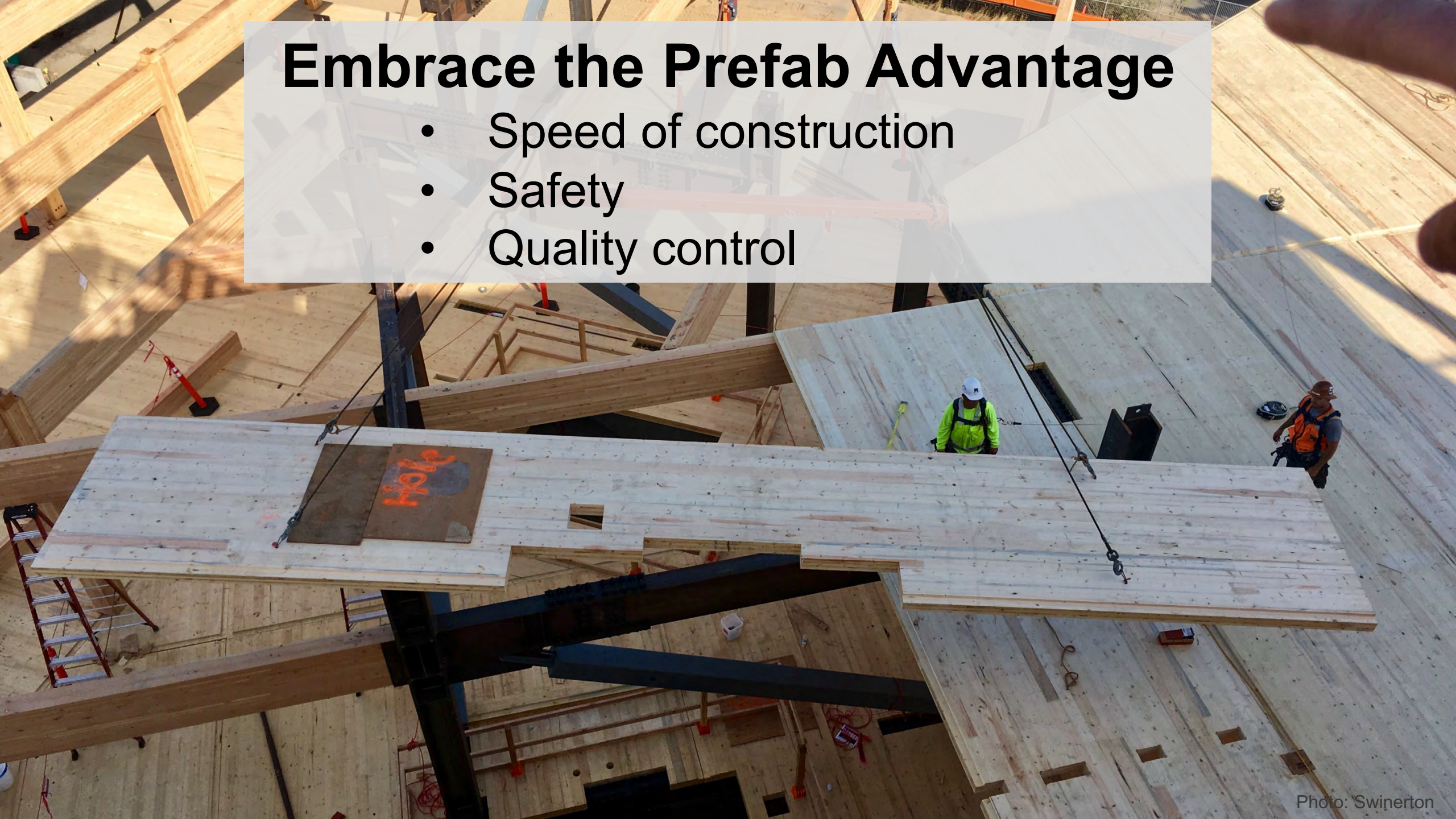
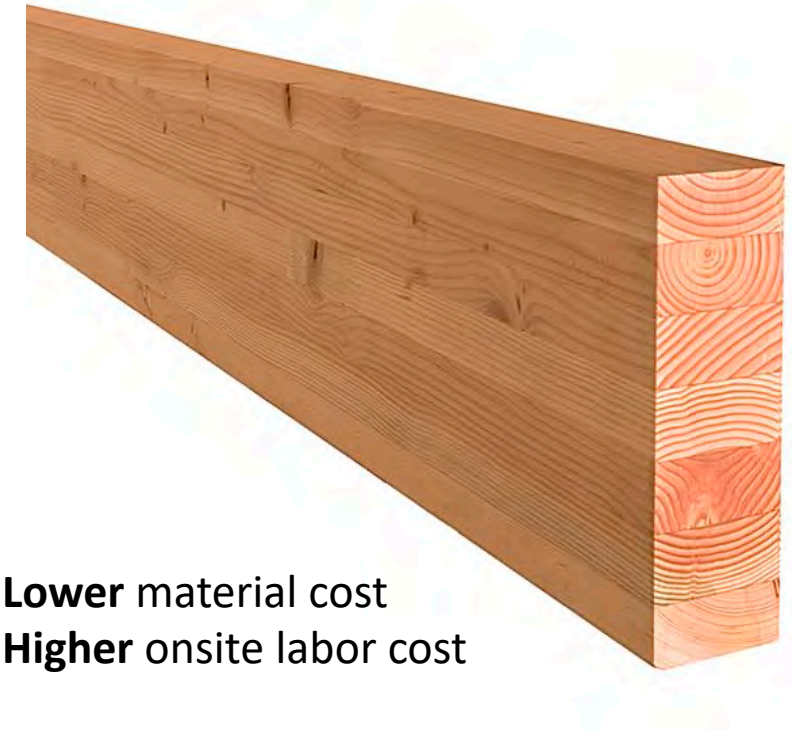


Photo: Swinerton

Levels of prefabrication: effect on material and labor costs



Lower material cost
Higher onsite labor cost

or

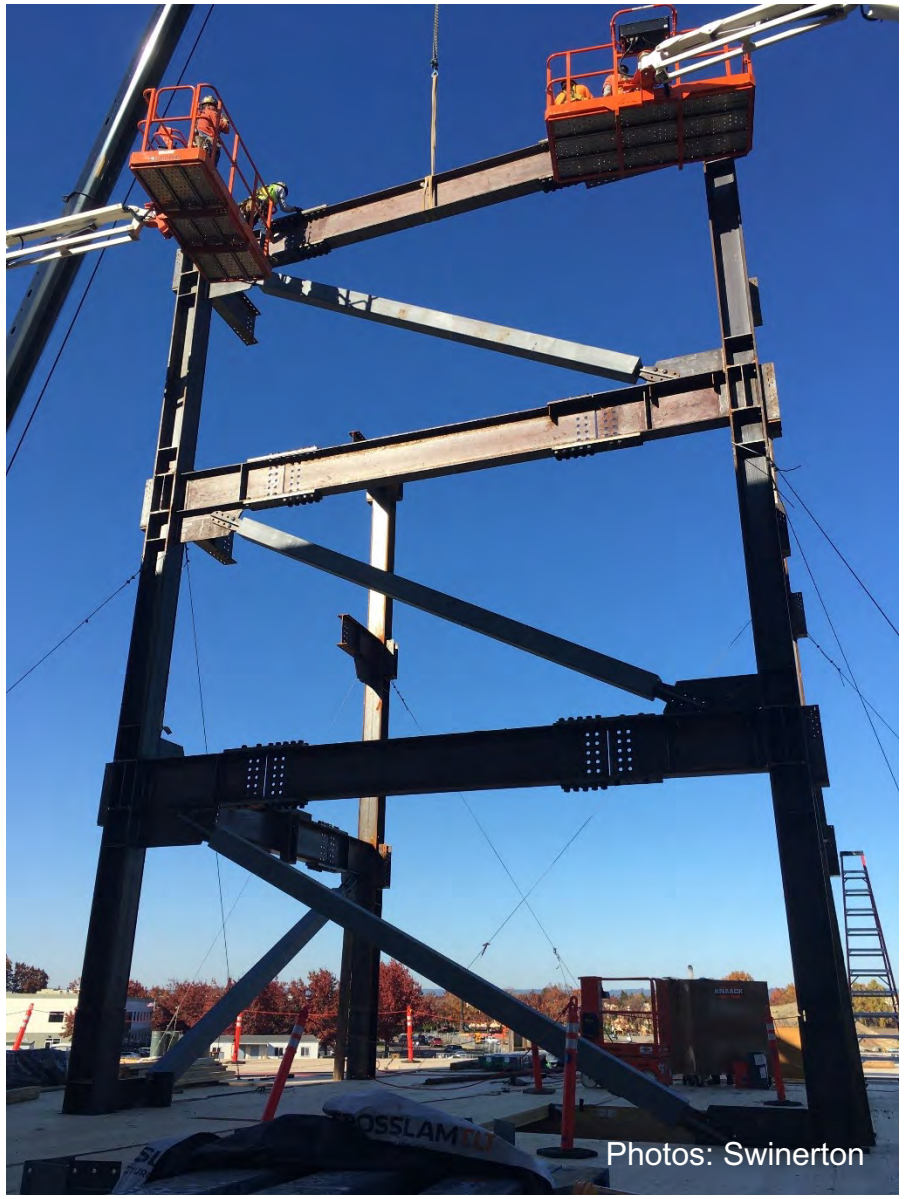
Higher material cost
Lower onsite labor cost

Source: Swinerton

Tolerances: Interface with Other Structural Materials

- Tolerance differences
- Buildable details!

Schedule Impacts: Hybrid Structures



Photos: Swinerton

Schedule Savings for Rough-In Trades

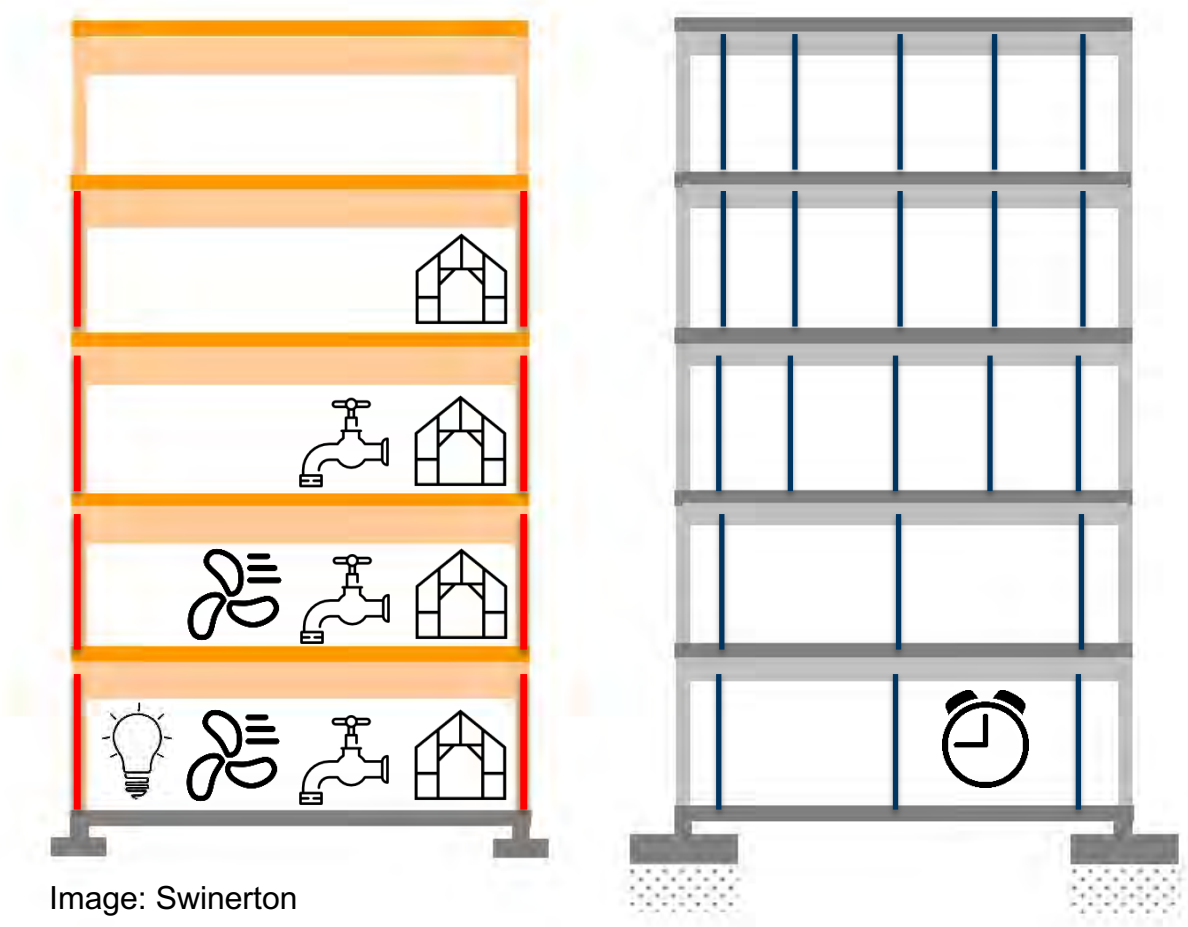


Image: Swinerton

Photo: WoodWorks

Value Analysis

$$\textbf{\textit{Value Engineering}} = \frac{\downarrow \textit{Function} + \downarrow \textit{Aesthetics}}{\downarrow \textit{Cost}}$$

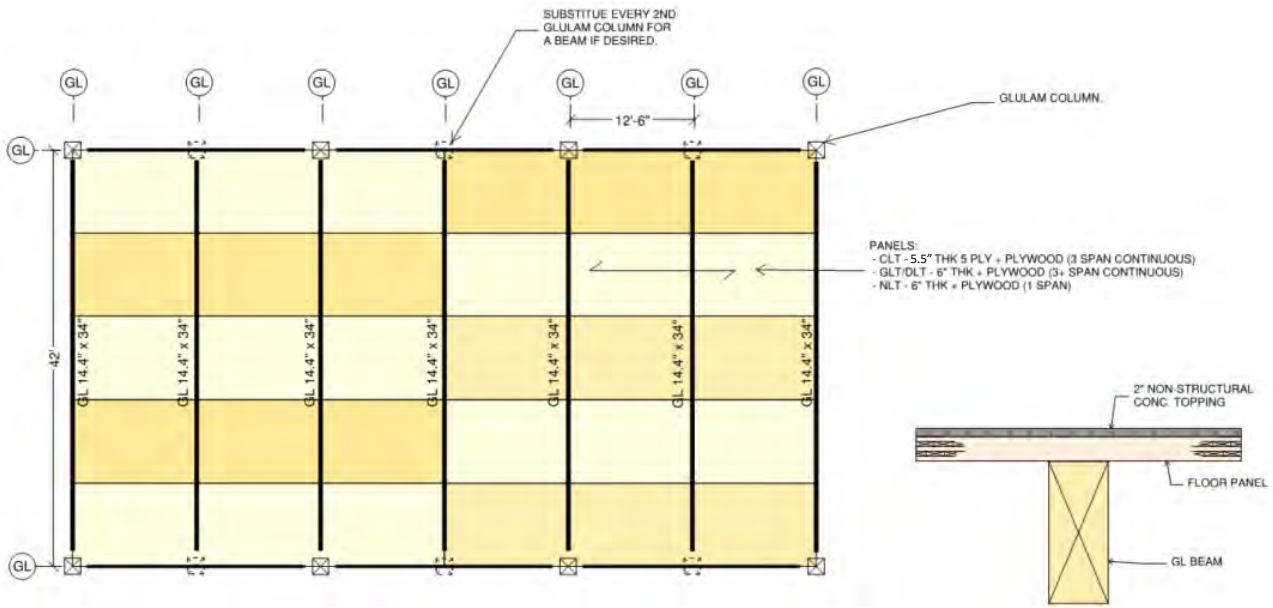
Value Analysis

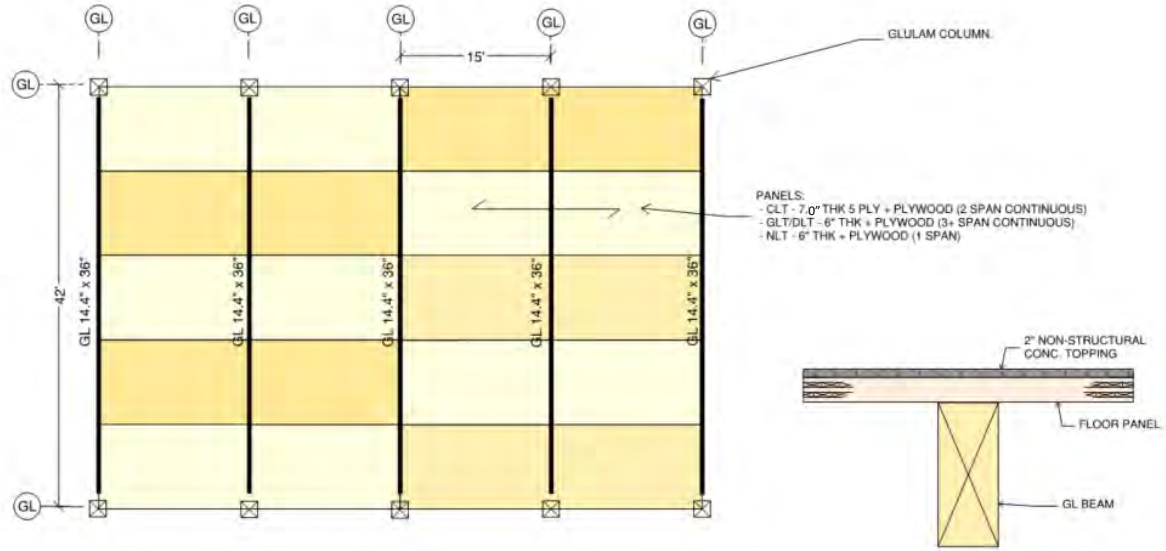
$$Value = \frac{\uparrow Function \quad + \uparrow Aesthetics}{\downarrow Cost}$$

Structural Grid Considerations

Photo: Swinerton

Structural Grid Considerations





Baseline

12’-6” Glulam Spacing

5.5” CLT

$ +5%

15’ Glulam Spacing

7” CLT

Source: Seattle Mass Timber Tower Book

How can I create an efficient structural grid for a mass timber building?

Mass timber products such as cross-laminated timber (CLT), nail-laminated timber (NLT) and glue-laminated timber (glulam) are at the core of a revolution that is shifting how designers think about construction. At no time has materials selection been such an integral aspect of the building designer's daily responsibilities. In addition to its sustainability and light carbon footprint, mass timber has benefits that include enhanced aesthetics, speed of construction and light weight, all of which can positively impact costs. However, to convince building owners and developers that a mass timber solution is viable, the structural design must also be cost competitive. This requires a full understanding of both material properties and manufacturer capabilities.

Mast timber is commonly seen in projects such as offices, schools and tall mixed-use buildings, which often have assumed structural grids. Intended to meet the need for tenant flexibility, these "default" grids align with the capabilities of materials historically used—i.e., steel and concrete. When it comes to laying out a structural grid for mass timber, the square peg/round hole analogy is pertinent. Although a mass timber solution may work economically on many grids conducive to steel/concrete framing, some grid modification may be valuable. Trying to force a mass timber solution on a grid laid out for steel and concrete can result in member size inefficiencies while negating opportunities related to manufacturer capabilities. As such, it is critically important to design a mass timber building *as a mass timber building* from the start. This requires a thorough understanding of how to best lay out the structural grid, without sacrificing space functionality, to optimize member sizes—but there's more to cost efficiency than column spacing.

The following considerations are based on a post-and-beam frame for occupancies such as offices; however, many also apply to bearing wall-supported systems in other occupancy types.

Grid Selection

Simplistically, there are two main grid options for mass timber buildings: square and rectangular. In deciding which to use, there are a number of factors to consider.

View All Expert Tips

Project Assistance

Our technical experts offer free project support from design through construction, on issues ranging from allowable heights and areas to structural design, lateral systems and fire- or acoustical-rated assemblies.

Get Assistance >

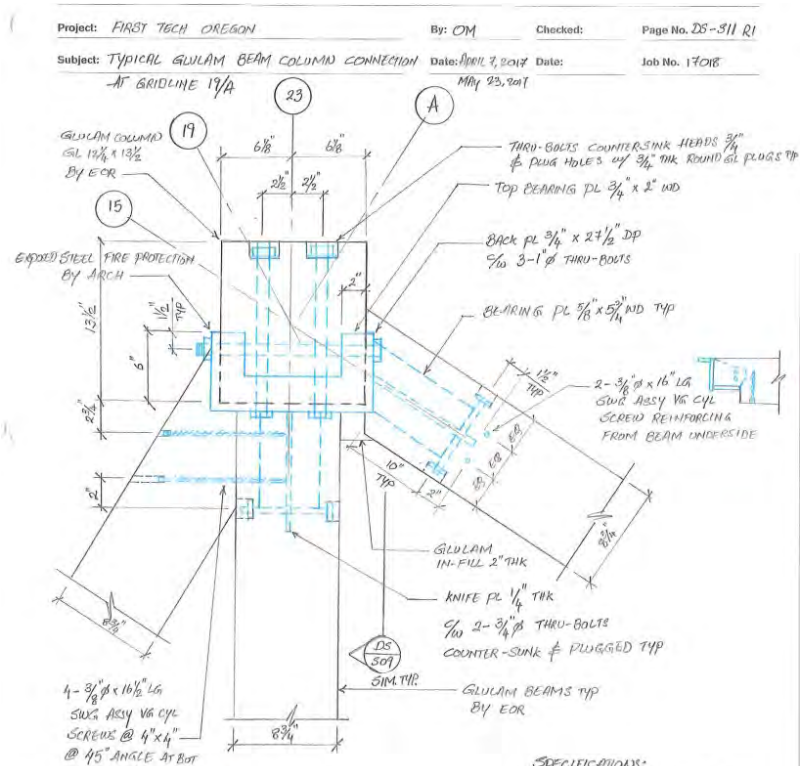
Ask an Expert

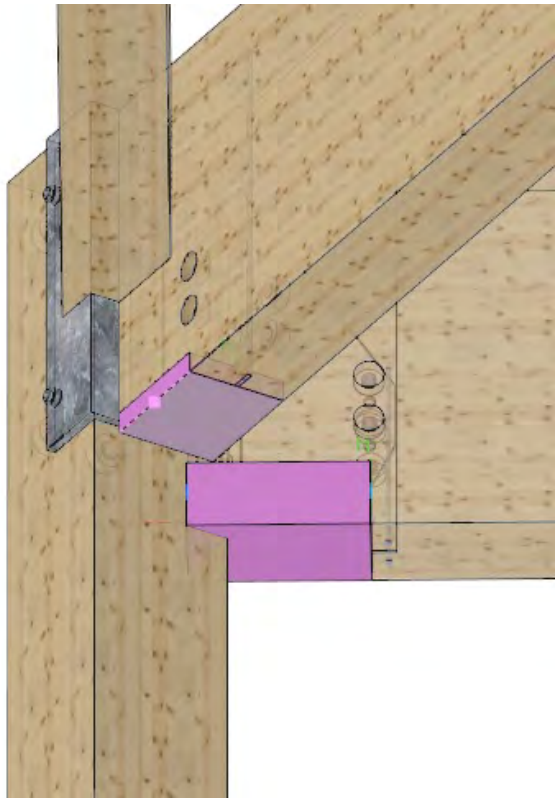
Q: What design and detailing considerations exist when splicing shear wall top plates at wall discontinuities?

A: Disruption of shear wall top plates can occur for many reasons—e.g., the presence of a continuous structural steel column within the wall, installation of plumbing vents, change in wall widths, or a slight jog in wall position. In some cases, a shear wall's top plates are used as chords and/or collectors for a diaphragm, meaning that discontinuities in the top plates create discontinuities in lateral load paths

Modeling

- Who is responsible?
- 2D or 3D?





Photos: Swinerton

QA/QC

- Starts with shop drawings, continues in field
- We are not fabricating onsite we are assembling onsite

Photo: Swinerton

Material Protection

Painting steel

Taping joints

Protect end cuts of timber

Photo: Structurecraft Builders

Photo: Alex Schreyer

Moisture Management Resources: Keep Wood Dry & Schedule on Track

Moisture Management Guide

(Light-frame & mass timber) **Download:**

https://www.bchousing.org/publications/Wood-Construction-Moisture-Management-Guide.pdf

Construction Phase Moisture Management, Section 7.6 NLT Guide (Good Tips for all MT)

Download:

https://www.thinkwood.com/products-and-systems/mass-timber/nltguide

Moisture Risk Management Strategies for Mass Timber (by RDH) Purchase:

https://learnbuildingscience.com/collections/guides-and-resources/products/moisture-risk-management-strategies-for-mass-timber-buildings

UNDERSTANDING INSURANCE

INSURANCE PERSPECTIVE ON MASS TIMBER

- Lack of historic loss data = Unknowns
- Unknowns = Risk
- Risk = Higher Premiums
- Some take a ‘wood is wood’ approach

- Important to understand the significant differences in how mass timber performs in the event of a fire, etc. when compared to light wood-frame and all other building materials

Photo Credit: StructureCraft

Photo Credit: GLI Partners

MASS TIMBER INSURANCE

- Mass timber insurance resource for insurers, developers, contractors & designers
- Free download at woodworks.org

Some mass timber projects have been classified as Modified Fire Resistive, but there is often pressure for underwriters to use more expensive classification codes. There is also interest in exploring a seventh classification specific to mass timber. Working with a broker experienced with mass timber is very helpful in terms of negotiating an appropriate classification. The broker can speak to its performance capabilities, advantages for the project at hand, and historical use in similar buildings.

While there are many types of insurance coverage for buildings, this paper is focused on general liability and property coverage for a building owner.

General liability coverage insures your legal liability to third parties for bodily injury and/or property damage. It covers both defense costs and any indemnity payments. There are exclusions for intentional acts, coverage that can be purchased under another policy, illegal acts and acts of government. General liability policy premiums are calculated based on employee payroll, revenue and the cost of subcontracted work, including materials. Rates vary based on specific tasks performed, location of the work, past claims history of the entity, breadth of coverage, the insurer providing the policy and negotiation skills of the insurance broker. Typical general liability limits are $1,000,000 for each occurrence, $2,000,000 general aggregate and $2,000,000 products/completed operations aggregate. This is considered a one million limit policy, as the occurrence limits are referenced in conversations about coverage. Aggregate refers to the maximum the policy will pay regardless of the number

General Liability Insurance Structure Options

For a developer of a mass timber project, there are two types of general liability insurance available.

The first covers just the developer's operations. This can be an annual renewable policy that is part of a larger program covering all of the firm's projects or a standalone policy covering a single project for its duration. In this scenario, the general contractor and each of the trade subcontractors purchase their own annual renewable policies. Annual renewable policies are called "practice" policies. A typical construction project has over forty applicable general liability practice policies, most of which include at least $5,000,000 in excess liability policies. Contractors and subcontractors are usually contractually obligated to name the developer as an additional insured on their policies.

The second option is a Controlled Insurance Program, which is called either an Owner Controlled Insurance Policy (OCIP) or Contractor Controlled Insurance Policy (CCIP), depending on whether the owner or general contractor is named first. These types of policies are issued for a specific project for all parties working at the site. They cover the term of construction through the statute of ultimate repose for the state where the project is located. Due to the depth and breadth of coverage, OCIPs and CCIPs are more expensive than practice policies. They're typically used when the owner wants to assign the liability coverage for a project to the insurance company, in order to end their liability when the project is sold. Sometimes a lender will require this type of insurance to provide clear liability pathways away from the

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Insurance for Mass Timber Construction: Assessing Risk and Providing Answers

One of the exciting trends in building design is the growing use of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall and roof construction. Mass timber products have inherent fire resistance and can be left exposed in many applications and building sizes, achieving the triple function of structure, finish and fire resistance. Because of their strength and dimensional stability, these products offer an alternative to steel, concrete and masonry for many applications, but have a much lighter carbon footprint. It is this combination of exposed structure and strength that developers and designers across the country are leveraging to create innovative designs with a warm yet modern aesthetic.

As mass timber construction has proliferated across the U.S., a number of project teams have run into the same issue: insurance companies unfamiliar with these types of buildings can be reluctant to provide insurance.

The challenge has presented itself in two forms: builder's risk insurance (or course of construction) and property insurance (after building is complete and occupied). Relative risks are assessed differently for each, and each requires a unique approach. For example:

- Construction-phase risks associated with fire are different in mass timber buildings than with most other framing systems. Since the timber elements have inherent fire-resistance capabilities, a building can have a certain level of passive fire resistance after the frame is erected. Protection doesn't rely on (and wait for installation of) materials such as spray-applied
- In addition to safety, property insurance for mass timber buildings requires an understanding of performance related to things like moisture, durability and building enclosure detailing. Much of the property insurance discussion is also site-specific—e.g., Is the area prone to flooding, earthquakes or high winds? Mass timber has been tested against potential natural disasters, and numerous test and research reports are available.

This paper is intended for developers and owners seeking to purchase insurance for mass timber buildings, for design/construction teams looking to make their designs and installation processes more insurable, and for insurance industry professionals looking to alleviate their concerns about safety and performance.

For developers, owners and design/construction teams, it provides an overview of the insurance industry, including its history, what affects premiums, how risks are analyzed, and how project teams can navigate coverage for mass timber buildings. Insurance in general can seem like a mystery—what determines premium fluctuations, impacts of a

Seattle Mass Timber Tower: Detailed Cost Comparison

Fast Construction

- Textbook example done by industry experts
- Mass timber vs. PT conc
- Detailed cost, material takeoff & schedule comparisons

"The initial advantage of Mass Timber office projects in Seattle will come through the

leasing velocity

that developers will experience."

- Connor Mclain, Colliers[1]

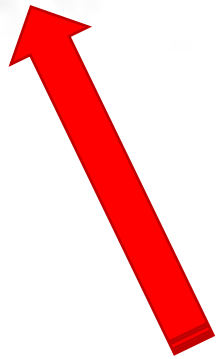
Download Case Study:

http://www.fastepp.com/wp-content/uploads/181109-Seattle-Mass-Timber-Tower-Book.pdf

Seattle Mass Timber Tower

Faster Construction + Higher Material Costs = Cost Competitive

System	Mass Timber Design	PT Concrete Design	Mass Timber Savings
Direct Cost of Work	$86,997,136	$85,105,091	2.2%
Project Overhead	$ 9,393,750	$11,768,750	-20.2%
Add-Ons	$ 8,387,345	$ 8,429,368	-0.5%
Total	**$104,778,231**	**$105,303,209**	**-0.5%**

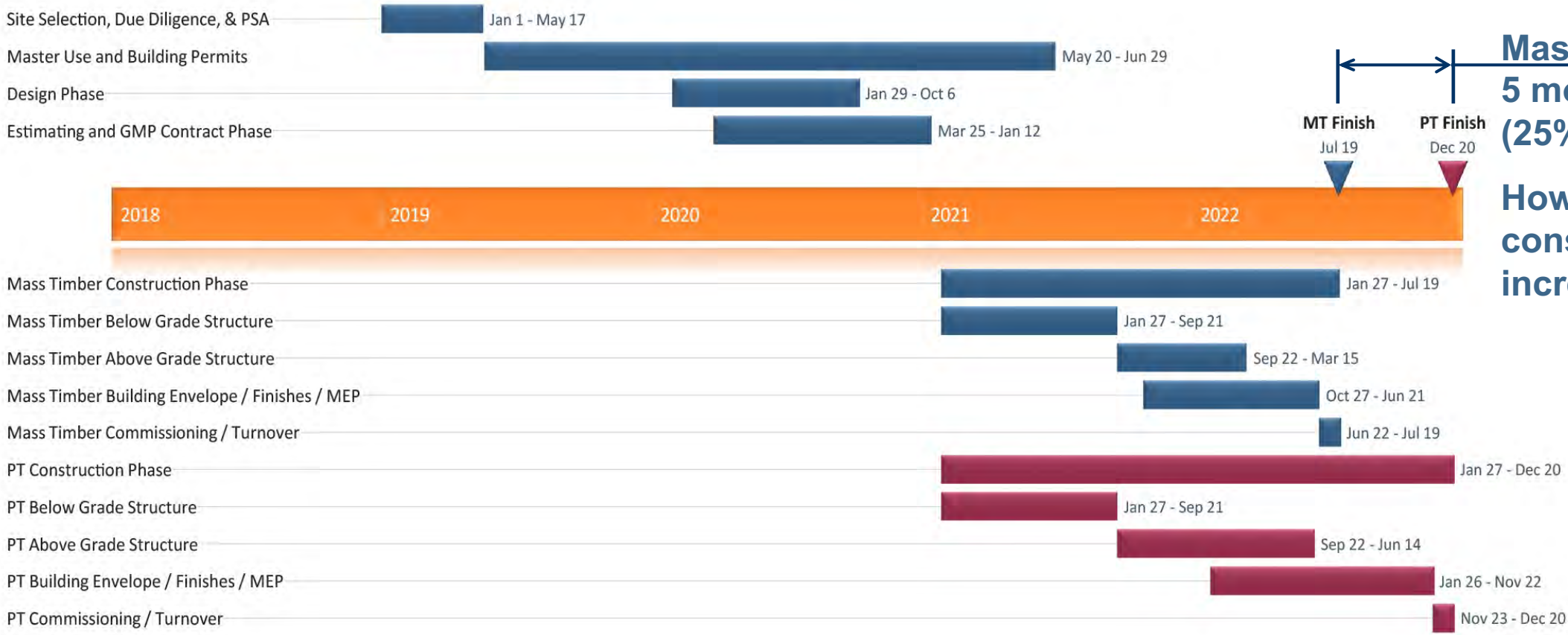


Source: DLR Group | Fast + Epp | Swinerton Builders

Seattle Mass Timber Tower

Fast Construction

Construction Schedule:



Mass Timber 5 months (25%) faster

How can faster construction increase your ROI?

Source: Tall With Timber
A Seattle Mass Timber Tower Case Study by DLR Group[1]

Reduce Risk
Optimize Costs

- For the entire project team, not just builders
- Lots of reference documents

Download Checklists at
www.woodworks.org

www.woodworks.org/wp-content/uploads/wood_solution_paper-Mass-Timber-Design-Cost-Optimization-Checklists.pdf

WoodWorks™
WOOD PRODUCTS COUNCIL

Mass Timber Cost and Design Optimization Checklists

WoodWorks has developed the following checklists to assist in the design and cost optimization of mass timber projects.

The *design optimization* checklists are intended for building designers (architects and engineers), but many of the topics should also be discussed with the fabricators and builders. The *cost optimization* checklists will help guide coordination between designers and builders (general contractors, construction managers, estimators, fabricators, installers, etc.) as they are estimating and making cost-related decisions on a mass timber project.

Most resources listed in this paper can be found on the WoodWorks website. Please see the end notes for URLs.

First Tech Federal Credit Union –
Hillsboro, OR

ARCHITECT:
Hacker

ENGINEERS:
Kramer Gehlen & Associates,
Equilibrium Consulting

CONTRACTOR:
Swinerton

PHOTO: JEREMY BITTERMANN

THE BUSINESS CASE FOR MASS TIMBER

George Fox University – Canyon Commons
Hacker | Photo: Jeremy Bittermann

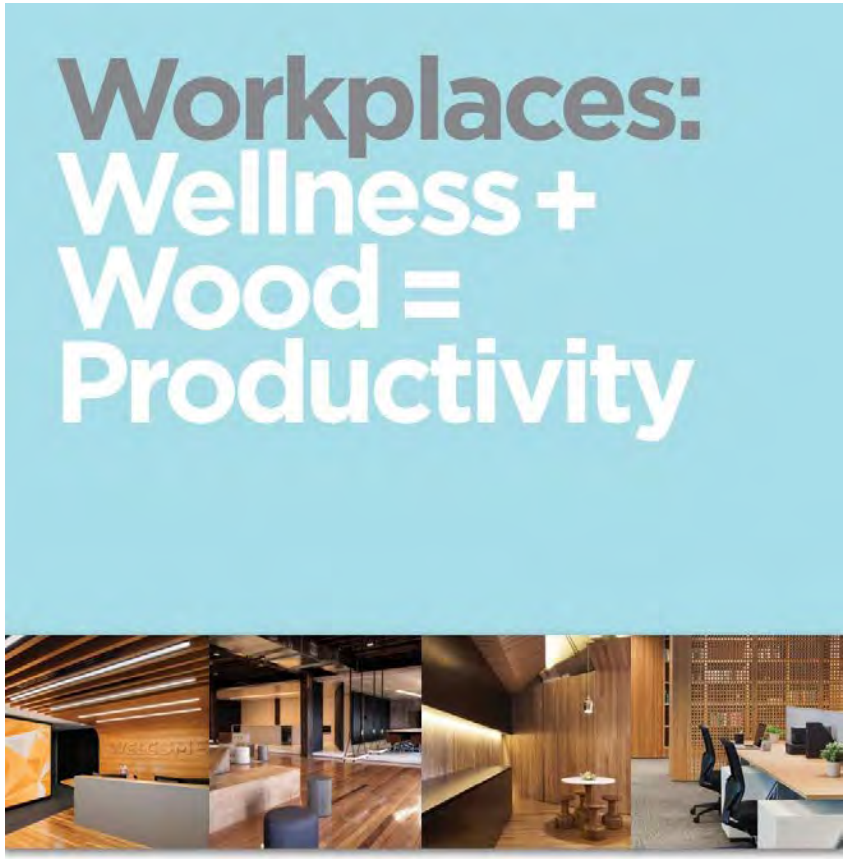
Workplaces: Wellness + Wood = Productivity
Healthy Buildings/ Biophilia

"Those in workplaces with a higher proportion of **visible wood** **feel more connected to nature** and rate their working environment far more positively."

These people report:

- lower stress levels
- lower blood pressure
- higher concentration
- improved overall mood

"Wood in the workplace is associated with **higher productivity** and **reduced sick leave**."



Report based on survey of 1,000 typical Australians working indoors


Environmental
Social
Governance
E
S
G
Climate change
Greenhouse gas (GHG) emissions
Resource depletion
Waste & pollution
Working conditions
Impact on local communities
Health & safety
Employee relations & diversity
Executive pay
Bribery & corruption
Political lobbying & donations
Board diversity & structure

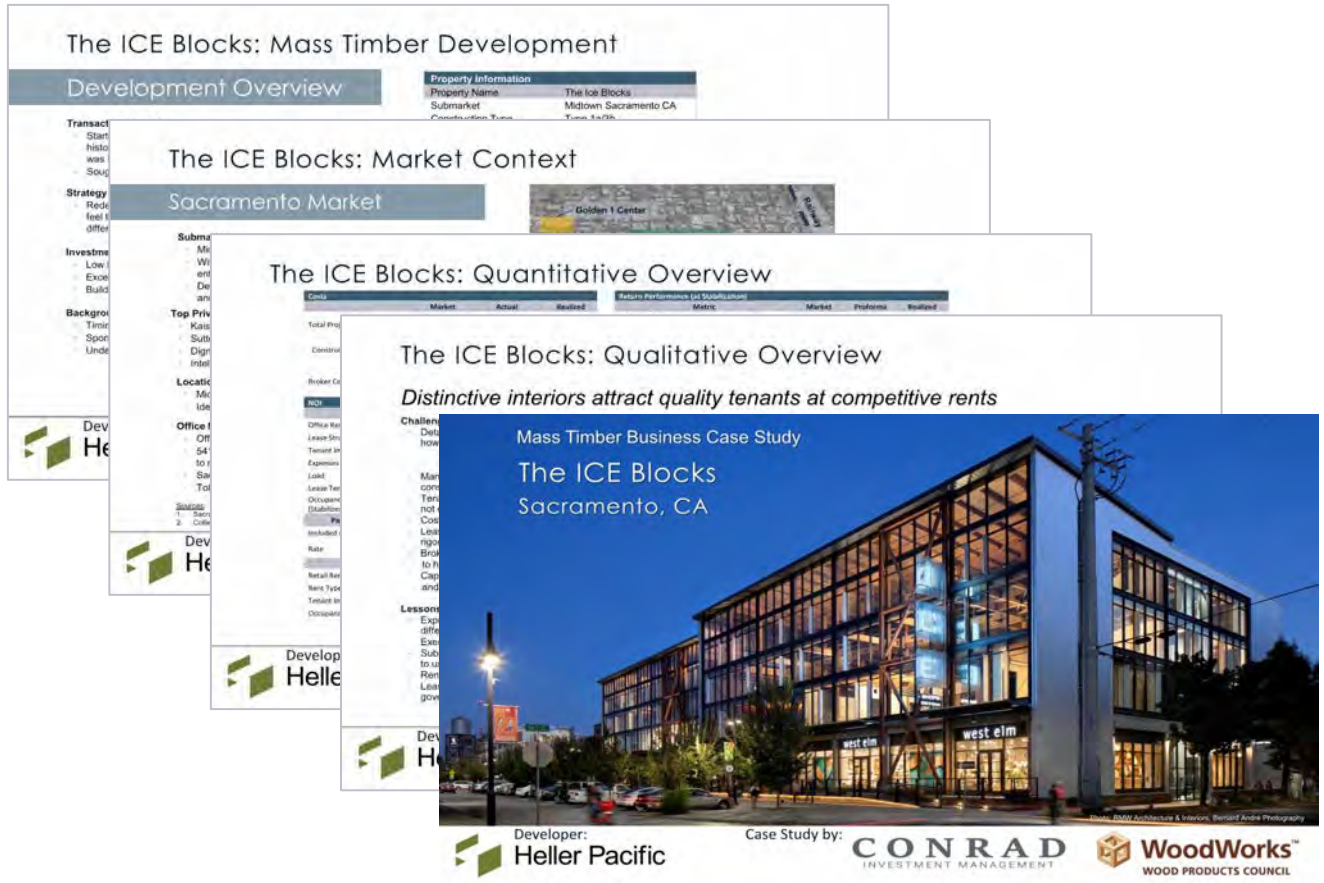
Tech Companies Invest in Healthy Corporate Campuses

Microsoft Silicon Valley Campus

Microsoft Campus | Image: WRNS Studio

Potential Benefits	Project Goal ✓	Value Add ✓
Fast construction/shorter schedules; pre-fabricated and precise		
Exposed wood (structure is finish!) • Aesthetic value; potential for faster leasing and lease premiums; portfolio distinction • Biophilia; healthy indoor environment		
Lightweight structure, especially beneficial on sites with poor soils		
Labor shortage solutions • Small crews for timber frame erection • Utilize more entry-level laborers when MEP and fire protection systems are fully designed, coordinated and pre-planned		
Just-in-time delivery and small staging/lay-down areas; ideal for dense urban areas		
Natural, renewable material; environmentally friendly with a lighter carbon footprint		
Support healthy forests and rural economies • Mass timber can be made from relatively small-diameter trees and those affected by insects or disease; creates a market incentive for forest thinning and other landscape restoration efforts that reduce the risk of high-severity wildfires		

Mass Timber Business Case Studies



Download online at

www.woodworks.org/mass-timber-business-case-studies

- Includes financial return performance data on mass timber projects
- Developers share lessons learned, challenges and successes

ICE Block I: California's First Modern Timber Office Building

Location: Sacramento, CA
Architect: RMW Architecture & Interiors
Engineer: Buehler Engineering

IIIB

- 3 Story heavy timber over podium
- 87,460 sf
- Aesthetic value is same for heavy & mass timber

"The **building sold itself** because of its unique character. There really was no true competition in the market. **A lot of the credit goes to the fact that it is a timber building**."

– Mike Heller, Heller Pacific

Clay Creative: Early Mass Timber Speculative Office

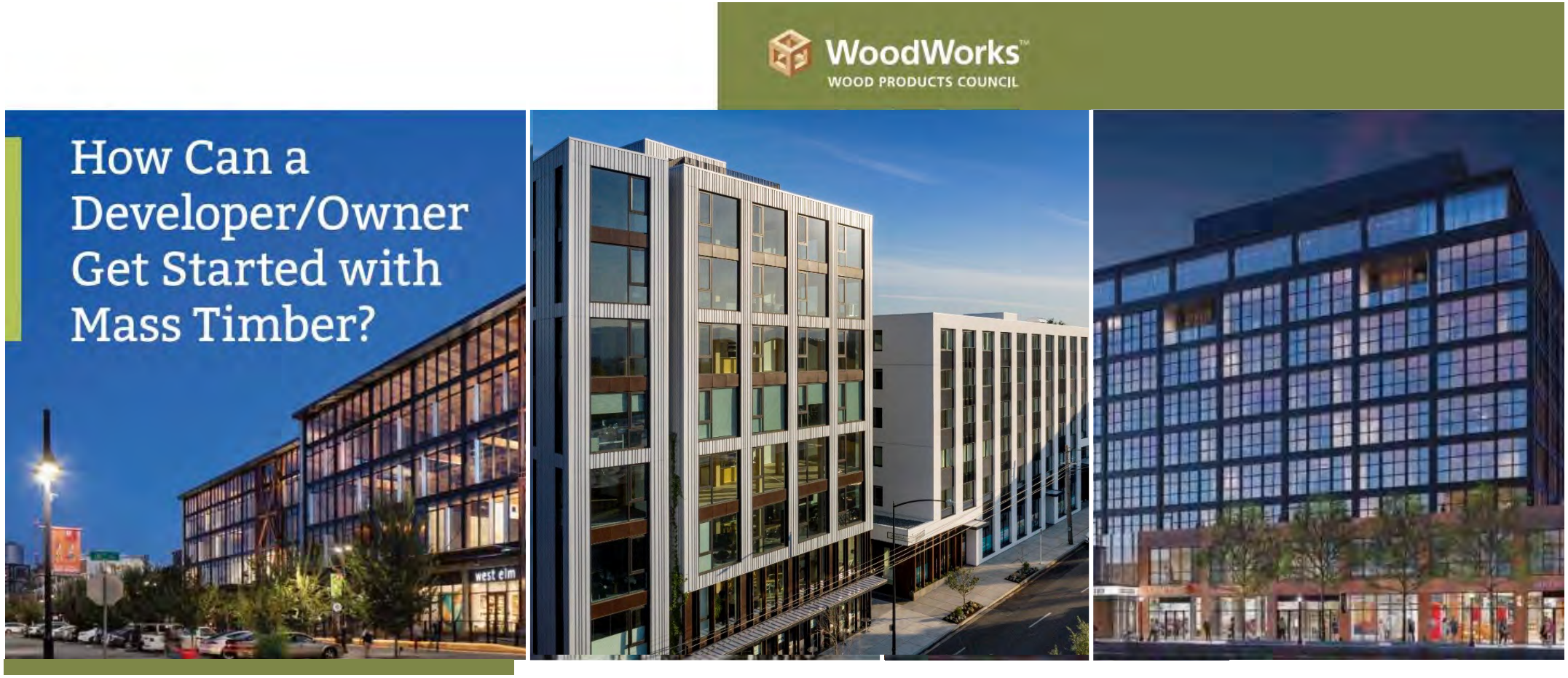
IIIA

- 5 Story Type IIIA
  over 1 story Type IA deck
- 92,000 sf
- Flexible, open office
- Fast construction, enabled TI build-out concurrent with core and shell
- Achieved fast leasing and attracted desirable tenants

Location: Portland, OR
Architect: Mackenzie
Engineer: Kramer Gehlen & Associates

Other Resources for Developers/ Owners

2-pager for Urban Land Institute (ULI)



www.woodworks.org/wp-content/uploads/WoodWorks_Getting-Started-w-Mass-Timber-2-Pager.pdf

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This concludes The American Institute of Architects Continuing Education Systems Course

Photo: Structurlam | Seagate Structures

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